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THE SMALLEST OF THE WILD CATTLE.

By R. Lydekker.

Among the larger mammals the species or varieties inhabiting islands are more or less markedly inferior in point of size to their nearest continental relatives. In the case of the smaller islands, like Sardinia and Corsica, the reason of such a diminution in stature is not far to seek, and it is therefore not in the least surprising to find that the Corsican red deer is a very inferior edition of its prototype of the mainland. The buffalo of the small island of Mindoro, in the Philippines, is greatly inferior in size to the wild buffaloes of the tall grass-jungles of Assam. In the case of islands of the dimensions of Sumatra and Borneo the reason of the phenomenon is by no means apparent, especially when we find them inhabited by a man-like ape (the orang-utan) almost rivalling in bulk and stature the gorilla of Western Africa. Nevertheless, even in such areas the same feature is to a certain extent noticeable, the wild buffalo of Borneo being considerably smaller than its Indian relative. As regards its actual area, the island of Celebes occupies a kind of intermediate position, since it is much inferior in extent to either Sumatra or Borneo, although far too extensive to come under the denomination of a small island. From its peculiar shape, which recalls the form often assumed by an amœba, it has, however, a much smaller area than could be enclosed by a ring fence than many islands of less than half its acreage, and this may really bring it, so far as the development of animal life is concerned, into the same category as a small island.

Be this as it may, Celebes has the distinction of being the home of the smallest living representative of the wild cattle, or, indeed, of the wild cattle of any period of the earth's history, for no equally diminutive fossil member of the group appears to be known to science. An idea of the extremely diminutive proportions of the anoa, or sapi-u'an, as the animal in question is respectively called by the inhabitants of Celebes and the Malays, may be gained when it is stated that its height at the shoulder is only about 3 feet 3 inches, whereas that of the great Indian wild ox, or gaur, is at least 6 feet 4 inches, and may, according to some writers, reach as much as 7 feet. In fact the anoa is really not much, if at all, larger than a well-grown South Down sheep, and scarcely exceeds in this respect the little domesticated Bramini cattle shown a few years ago at the Indian Exhibition held at Earl's Court.

The anoa has many of the characters of the large Indian buffalo, but its horns are relatively shorter, less curved, and more upright. In this, as well as in certain other respects, it is more like the young than the adult of the last-named species; and as young animals frequently show ancestral features which are gradually lost as maturity is approached, it would be a natural supposition that the anoa is a primitive type of buffalo. This idea receives a remarkable confirmation from the circumstance that in the latter Tertiary strata of Northern India there occurs skulls of anoa-like buffaloes, which, however, in correlation with the continental area where they are met with, indicate animals of considerably larger dimensions than the living Celebes animal. In fact the latter, together with the somewhat larger wild buffalo, or tamarau, of the island of Mindoro, and the aforesaid extinct Indian species, constitute an altogether peculiar and primitive group of the buffalo tribe.

In its young state and during middle life the anoa is covered with a fairly thick coat of somewhat woolly hair, which is at first yellowish brown, but eventually becomes dark brown or blackish. In common with other Asiatic buffaloes, the hair is reversed along the middle line of the neck and back as far as the haunches; that is to say the tips are directed towards the head instead of towards the tail. What may be the precise object of this reversal (which is also met with among many antelopes and deer) is not yet ascertained. Possibly it may have something to do with the manner in which the animals rub themselves against the stems or boughs of trees and bushes.

In old individuals, especially those of the male sex, the coat of hair almost completely disappears, leaving the black skin bare and shining, like that of old buffaloes in general. This condition has been attained by the bull shown in the foreground of the accompanying photograph. And here it should be remarked that this particular animal has suffered the loss of the greater portion of its tail, which somewhat alters the appearance of its hindquarters. And, with the usual fatality that attends the grouping of animals, it has happened that the hind-quarters of the bull are in full view, while those

of the cow are concealed! The somewhat spiteful and uncertain temper of the bull is indicated by the circumstance that it was found necessary to affix brass knobs to its horns. From the more typical buffaloes the anoa

Male and Female Anoa at Woburn Abbey.
From a Photograph by the Duchess of Bedford.

differs by the general presence of white markings. These usually take the form of a gorget on the lower part of the throat, and of one or two spots on each side of the under jaw, as well as patches above the lateral hoofs; but there may also be white blotches on the neck and back, and in front of the eyes, while more or less of white may appear on the muzzle and the whole of the lower portion of the limbs. The special interest attaching to these white markings is that the spots on the sides of the face as well as the gorget on the throat are also met with among certain antelopes, such as the kudu and the bushbucks; and from this it has been inferred that the anoa is more nearly related to the antelopes than is any other member of the ox tribe. Although this may be true to a certain extent, the connection with the kudu tribe is remote.

According to the meagre accounts we at present possess of the creature in its native haunts, the anoa dwells in pairs on the elevated ground of the interior of Celebes, where it passes most of its time in thick forests in the neighbourhood of water. In associating in pairs it is quite unlike all other wild cattle, with the possible exception of the Philippine tamarau; and here again it presents a resemblance to the kudu and bushbucks, which also generally go about in pairs or small family parties.

Examples of the anoa are but rarely seen alive in England, although they do not appear very difficult to procure. The first specimen exhibited in the London Zoological Gardens was purchased in May, 1871, and a second was obtained by exchange in June, 1880. Between the latter date and 1896 (when the last complete list of the animals in the menagerie was published) not a single example of this very interesting little buffalo was obtained. At Woburn Abbey the pair represented in the accompanying photograph dwelt in a good-sized paddock by themselves and flourished for a considerable period. Unfortunately, however, one of the two has died since the photograph was taken.

Apart from the interest attaching to it as a primitive island type, and as being the smallest representative of the ox tribe, it cannot fairly be said that the anoa is a very attractive animal. It has nothing specially to commend it from an æsthetic point of view, being, in fact, a rather ugly and ungainly creature; and from its pugnacious disposition it is not adapted for turning out in British parks among other horned animals. Moreover, it has a decidedly delicate constitution, which alone would be sufficient to render it unfit for this kind of life.

THE BORDERS OF THE KARST.

By Grenville A. J. Cole, m.r.i.a., f.g.s., *Professor of Geology in the Royal College of Science for Ireland.*

If we ascend the Predil Pass from the Karinthian side, we rise above the fields of Villach to the typical landscapes of the Eastern Alps. At Raibl we are surrounded by the *débris* of the crags, and the white pebbles fill the valley-floor; still climbing, through the last fir-woods, we look down into the rich green Raibler See, and then up to the notch that forms the passage through the limestone crests. After that all is limestone, down to the very shores of the Adriatic, and there we approach, with a feeling of satiety, the bare white plateaux of the Karst.

The learned Mojsisovics* reminds us that the Karst is occasionally clothed with grass upon its summits, and with woodland on its flanks towards the sea. Anyone who has gazed upon the Karst will feel, however, that he must insist on its essential barrenness.

The Aran Isles off the coast of Clare, and some surfaces in the west of Yorkshire, may give us an introduction to the nakedness of the Karst. In a limestone country, where storms prevail, on the one hand, or where dry seasons parch it, on the other, such soil as may be formed has little chance of preservation. The exposed surface becomes worn down along the planes of bedding of the strata; if these are gently tilted, the bare dip-slope may extend for miles; if they are horizontal, a dreary and unbroken plateau may result. Solution sets in along the prevalent joint-planes, and great open grooves arise, like the crevasses in the surface of a glacier. The water missing from the surface is found again underground, where it dissolves away the rock, and forms chains of caves and passages as it flows.

As we swing down the great curves of the Predil, under the peaks of the Mangart and the Terglou, the pebbly floor assumes more and more a feature of the landscape. The vegetation on the shifting limestone surfaces becomes broken up into little clumps, and acquires the monotonous dull green tint that seems characteristic of the east. The road in summer lies inches deep in hot white dust, as the Slovenian peasant knows too well, trudging down the ravine behind his thirsty flocks. At length we emerge on the plain of Görz, where Eocene sandstones and marls lend some diversity.† But there is a grim touch of the genuine Karst in the ridge that has still to be encountered, before the Italian deltas come in view.

The landscape reminds one mostly of pictures of

* "Zur Geologie der Karst-erscheinungen," *Zeitschrift d. deutsch. u. oesterr. Alpenvereins, 1880.*

† *See* L. K. Moser, *Der Karst und seine Höhlen* (Trieste, 1899), p. 11.

the Holy Land. Stone walls bound the fields, scarcely distinguishable from the bare edges of the strata as they come out, one above another, on the hill. Dull lumpy trees, and forlorn patches of scrub, make dark spots upon the slopes, and gather together a little more closely in the shelter of some waterless ravine. The forlorn hamlet of Doberdo, by its name, should still be a Slavonic village; but from it we look down to the Adriatic, where the Italian population clusters along the shore. The delta below is covered with trees, and still banks us out from open water. As we drop from this bare dry summit to Monfalcone, we see the hills rising, one beyond another on our left, all of the same character, terraced with limestone edges, and spotted grudgingly with trees. The limestone here is Cretaceous, but the Eocene sandstones lie along the sea-front from below Nabresina to Trieste.

The plateau above Trieste, to an eye fresh from the riches of Karinthia, is a scene fraught with desolation. About Nabresina, it is fair to say that continuous quarrying has made the country still more stony. The Romans built Aquileia from the Eocene and Upper Cretaceous limestone of these plateaux,‡ and lowered the blocks down an incline to the quays below. The great railway-embankment made in 1853 was constructed entirely from the rubbish rejected by the Romans. It is strange that Aquileia, since the assault of Attila, has completely disappeared; its walls and towers, villas and temples, have merely served to extend the desolate Karst from which it rose.

Various limestones go to form the plateaux that stretch southward, from the foraminiferal strata of the Eocene down to the Triassic dolomites. The main mass was upheaved by the first important Alpine movements, and the beds following the Eocene were laid down in freshwater basins.§

The Dinaric Alps are a somewhat early offshoot of the great Alpine system, and the surface now formed by denudation often follows the dip-slope of broad and gentle folds. The feature insisted on by Mojsisovics‖ is the occurrence of infilled lake-basins on this limestone surface, many of which date from Miocene times. These may easily be picked out on any detailed map, such as the Austrian staff-map on the scale of 1 : 200,000. The name "polje," or field, is given to them by the peasants, and is applied also to the alluvial stretches along the great rivers of Croatia. The Glamočko Polje north of Livno is a fine example, in a closed basin 300 metres deep, thirty kilometres long, and fairly in the strike of the Triassic and Jurassic limestones. Modern alluvium partly covers the freshwater Tertiary deposits; but no water escapes from the hollows along the surface, and the streamlets that occur disappear here and there into the ground. The northern end is still occupied by a marsh. Mojsisovics ascribes the formation of these basins to the closing of valleys of erosion by barriers raised across the courses of the streams. "Almost every larger valley-system in Bosnia," he remarks, "possesses one or more Tertiary lake-basins. The old lakes are hence a common and characteristic feature of the Bosnian valley-systems, and their origin must be due to some cause operating on a wide scale, and affecting the whole region equally. The disturbances exhibited by the Newer Tertiary formations within the basins indicate that the upheaving forces in these districts were still in full activity, even in the most recent period."

Similar infilled basins, usually traversed by the rivers along which they have arisen, occur throughout the wooded region of the Bosnian highlands, on the east side of the typical and barren Karst. The plateau-country extends from Trieste through Dalmatia, West Bosnia, the Hercegovina, and Montenegro, and much is now being done by the Austrians to store up its water and to encourage the growth of trees.¶ The numerous small funnel-shaped depressions, called simply "dolinas," or valleys, by the Slavs, show how the atmospheric waters soak into the surface and enlarge their vertical channels by solution. But for a few artificial wells and cisterns, hundreds of square miles of the Karst-land would be practically impassable.

Asbóth,** whose admirable and unassuming book stands out amid all that has been written upon Bosnia, gives us some characteristic pictures of the south. Here is one from the neighbourhood of Mostar:—"Our eyes rest on nothing but cliffs and boulders, and between the stones venomous snakes and scorpions, long lizards, the carcases of dead animals, and the stumps and roots of fallen trees. The sky is of a transparent pale azure, the rocks ashy-grey, here and there changing into sand colour or rusty brown, the sparse vegetation being of a melancholy greyish-green. The whole, a Southern solitude, almost a desert, inhospitable and bare; and yet withal beautiful."

And this picture from Gacko, on the Montenegrin frontier:—"One feels that those who cling to this soil are born for battle. . . . Ashy-grey or glaring ochre-coloured stones of all sizes, from entire mountain masses, enormous blocks, and lofty pointed pyramids, down to small boulders, which everywhere cover the ground, and especially where there are passes leading across the Saddle. . . . Vegetation is almost entirely lacking, as is also water. Very seldom does a spring show itself, and then rapidly vanishes again amidst the chinks in the rocks, after having created a small oasis of green."

On the east flank of the Dinaric Alps, the Cainozoic earth-movements have brought up Palæozoic rocks along the folds, and a far greater diversity of scenery is the result. But a true Karst-land, formed of Cretaceous and Jurassic limestones, extends between Banjaluka and Jajce. The old road left the Vrbas valley just above the suburbs of Banjaluka, and struck up to the plateau, coming into more pleasant country as it dropped on to the long band of Lower Triassic sandstone at Varcar Vakuf. The new road, however, has been now carried up the gorge, which was previously inaccessible, even to pedestrians; its walls provide superb sections in the materials that form the Karst. Though the plateaux throughout Bosnia often coincide with the crests of broad and simple anticlinals, or with the level central portions of denuded synclinals, much subsidiary folding may occur within the limestone mass. Great thicknesses of the pale Jurassic and Cretaceous limestones have been brecciated, apparently by the Miocene earth-pressures, and the constituent blocks, ovoid and squeezed together, form a characteristic feature of the sections. Near Jajce itself, at the close of a series of magnificent

‡ Moser, *op. cit.*, p. 10.

§ A. Bittner, in *Grundlinien der Geologie von Bosnien-Hercegovina* (1880), p. 240.

‖ *Op. cit.*, and also *Grundlinien der Geologie von Bosnien-Hercegovina*, p. 61.

¶ *See* H. Renner, *Durch Bosnien und die Hercegovina kreuz und quer*, 2te. Auflage (1897), pp. 325–354.

** "An Official Tour through Bosnia and Herzegovina," English edition (1890), pp. 273 and 325.

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ravines, the contortions and overfolds in the Jurassic beds can be clearly traced upon the great rock-walls. The passage of fifty miles up the river lies almost entirely in the limestones; near its close we come out abruptly on the Newer Cainozoic conglomerates of Jajce, which contain pebbles of the rocks that form the Karst. Here denudation has cleared out a sort of amphitheatre, at the head of which the town and castle stand. Part of this basin has been filled up by recent travertine, yet another type of limestone, which forms massive beds, cut through by the Vrbas and the Pliva. The Mohammedan town, climbing up a conical hill, is thus actually built on material brought in solution from the Karst. The modern waters are still adding to this deposit, trickling through the interstices of the tufa, and forming new films and stalactites in the clefts.

Above Jajce, the wooded valley runs at first in the Palæozoic shales, which tend to pass into mica-schists. Now and then a brecciated limestone comes in, with faults and slickensided surfaces, and probably also of Palæozoic age.†† Palæozoic limestones are, indeed bent up to form plateaux east of Bugojno, which repeat the characters of the great Karst-land to the west.

Between Donji Vakuf and Gornji Vakuf, two highly typical Bosnian villages, the elongated "polje" of Bugojno extends. The hills fall back on either hand, and here and there across the level cultivated land one can see the mouth of some gorge in the Karst, guarded by a ruined tower. In late Cainozoic times, when the basin came into existence, the streams from the limestone plateaux speedily converted it into a lake; but their clear hard water flowed through it, bringing down scarcely any matter in suspension. Consequently, the freshwater molluscs, *Limnæa* and so forth,‡‡ flourished in the lake, and their activity formed the fine chalky limestone, the so-called "shell-marl," that ultimately filled the basin. A true alluvium, deposited in modern days by the Vrbas, covers the central part of the area.

The road up this part of the valley has a very English air, gently winding between fine old hedgerows, which were planted in the Turkish days. Down among the willows, a man and his horse are bathing together in the stream, and the two figures are as simple and natural as a scene from prehistoric times. In a small field, three horses, tied to a post, run round and round, treading out the corn; while the winnowing is done, in a more open area, by a turbaned peasant, who flings up the grain with a shovel into the air. The stream shining in the sunlight, the life of the Bosnian homestead, the light wind blowing away the chaff, and the far-off piping of some herd-boy seated in the shadow of the woods—here you have the "polje" at its fairest, the oasis set against the Karst. Above Gornji Vakuf all this ceases; we plunge again into the beech-forests, and begin the ascent of the watershed between the Black Sea and the Adriatic, which has been chosen as the natural boundary between Bosnia and the rugged Hercegovina. The woods of beech and young oak cover the lower hills completely, but leave long grass-slopes on heights of five thousand feet or more. On the *col* of the Maklen Pass (1123 metres), there is a little clearing, and then we look out from the northern forest into a new and rock-girt world. The mountain-side drops steeply from our feet, and the Alpine road goes down in windings, like a white serpent, to the mosques and roofs of Prozor. The bare cliff of Triassic limestone on which we stand is succeeded by a park-like region, again due to the presence of Newer Cainozoic beds; but beyond and above this smiling foreground rise, tier upon tier, the craggy walls of the Hercegovina, culminating in the Prenj planina, 7000 feet above the sea. Seen from this distance, the country is clearly a huge plateau intersected by ravines. Beyond Prozor, we run abruptly into one of these gorges in the limestone. There is just room for the road in the notch through which we pass; then we swing down and down, curve after curve, into the great Rama vale below. Here we are lost among the rocks, driven onward, like the stream, along the one passage opened through the country; now and again, what looks like a knife-cut appears in the precipice on our left, where some tributary has worked its way down from the level highland of the Karst. The ravine, in the heat of a Dinaric day, is always deep in shade; at its foot, we run out into the still nobler valley of the Narenta, and halt for the night under the Prenj crags in an amphitheatre worthy of Tyrol.

Here the way is open to the Adriatic, through the great gorge that cuts across the Karst, past the barren slopes of Mostar, and down to the marshes of the Dalmatian shore. The sun beats upon the precipices, and makes each cirque a white furnace in the hills. The river itself shrinks among its stone-banks, leaving on its edges green and stagnant pools. The lizards, revelling in the noonday glare, lie motionless on gleaming slabs of rock; far up, one may see an eagle, sailing across the pale blue-purple of the sky. Perhaps it is time to turn northward, to cross the Ivan Saddle, and drop through the cool dark woods to Sarajevo.

†† Compare Mojsisovics, *Grundlinien, &c.*, pp. 58 and 56.

‡‡ Mojsisovics, *ibid.*, p. 63.

ON THE RESPIRATION OF CERTAIN DRAGON-FLY NYMPHS.

By the Rev. Arthur East.

The question as to the method of respiration amongst the various members of the family of the Odonata is admittedly an obscure one, and the following observations will, it is feared, not tend much to elucidate matters, but are intended only to draw attention to a point which does not appear to be generally recognised. That the question is one requiring careful investigation may be inferred from the following instance. One family of the dragon-fly group is furnished with certain leaf-like appendages to the extremity of the abdomen, which are known as the caudal lamellæ. These organs are closely connected with the tracheal system, no doubt acting in the same way as the gills of a fish, and extract the air dissolved in the water — in fact the nymph breathes by means of them. But of the three caudal lamellæ which these Zygopterid nymphs normally rely upon for supplying them with air, which is as essential to them as it is to us, often one, or two, or even all three are missing; lost to their owners by some untoward accident. Of one member of this group, Mr Lucas, in his book on the British dragon-flies, even writes that *Agrion puella*, as bred by him, *usually* lost its lamellæ before emergence, and yet, strange to say, the nymph appears quite as happy without its breathing apparatus as with it, and only suffers inconvenience, apparently, from the loss of its propeller, which function the caudal lamellæ also fulfil. It is believed that the process of breathing may be performed through the skin. A nymph recently placed in water, together with a small quantity of indigo, in order to see whether any stream

of liquid could be detected entering and leaving the abdomen, as in the other chief group of the Odonata, was found to be stained with the pigment in the five last segments of the abdomen, the other segments, together with the head and legs remaining green, as before, but the proof that the pigment was drawn in by respiration through the skin was not by any means conclusive.

The other chief group of the Odonata perform the act of respiration in a different manner. The abdomen terminates in five more or less pointed appendages, two of them short and three longer.

In *Æschna cyanea*, a member of the Anisopterid group, two of these latter appendages are sharp spines, and are used as weapons of offence; the third, which is called the upper anal appendage, is somewhat obliquely truncated, and all three are grooved within, forming a minute channel when closed together. The effect of the upper anal appendage being truncated is that this channel, fine as a small bristle, is always open to the element the nymph is in, whether air, or water, even when the spines are quite closed.

Ordinarily these spines are kept wide open, and water is admitted to the interior of the abdomen and expelled therefrom by the regular dilation and contraction of the ventral side of the abdomen, the dissolved air being abstracted by certain folds in the last part of the intestine and distributed thence through the tracheal system.

The rate of breathing, which is very easily observed, varies from about thirty pulsations a minute to twenty, seventeen, or even thirteen a minute, the nymph at times remaining for several minutes at a time with all the anal spines closed, and without any perceptible dilation or contraction of the abdomen.

Now the fact of this anal channel always remaining open, even when the spines terminating the abdomen are closed tightly together, is connected with a very extraordinary faculty possessed by one at least, and possibly all, of the members of this group of the Odonata.

Of more than two hundred individual nymphs of *Æschna cyanea* observed, every one spent about the last two weeks of its aquatic life (minus the final two or three days) with the tip of the abdomen clear of the water, and the anal passage open to the air; when disturbed the nymphs would descend a short distance down the stick they rested on into the water, and return very shortly to their former position. During the two or three days immediately preceding emergence the position was reversed, and the head and thorax were protruded into the air as far as two large breathing apertures on the fore part of the body, called the thoracic spiracles. These spiracles under a lense could be seen to be open and they are connected with well developed tracheæ. This habit suggests very strongly that during the last fortnight of its aquatic life the nymph breathes the outer air direct into the tracheal system.

Being anxious to know whether this faculty is confined to the later nymph stages alone, the writer lately procured some nymphs of *Æ. cyanea*, about $1\frac{1}{4}$ inch long, and kept them out of water in damp weed, and the result is not a little surprising. Two nymphs have been living out of water for more than two months with only "short intervals for refreshment," and are as well and vigorous when put back into water as when first removed from it, and take their food with the wonted appetite of their kind; the intervals between visits to the water have varied from two days to twenty-eight days, and the times in the water have varied from two minutes to twenty hours; during its aerial periods the nymph is perfectly quiescent on the weed, and resumes its aquatic life exactly where it left off. Nor does this extraordinary faculty of living in both elements alternately seem confined to nymphs of which *Æ. cyanea* is an example.

Four nymphs of the Zygopterid group, viz., *Agrion puella*, have lived under similar conditions for thirty-three days without visiting the water at all, and appear perfectly vigorous and healthy. Similarly *Erythromma Naias* lived from March 16 to April 16 in damp weed only.

The present writer was led to investigate by the accident of leaving one nymph for some days in an empty bottle by mistake, and finding it well and hearty at the end of that time. It is true that this observation was only made on three species, but they are representative of both the Anisopterid and Zygopterid groups, and there is no structural reason why the same faculty should not be possessed by all the Odonata nymphs in an equal degree.

This faculty seems to be closely akin to that of the common crayfish of our streams, of which Huxley, in his "Introduction to Zoology," writes: "As is the case with many fishes, the crayfish breathes very well out of the water if kept in a situation sufficiently cool and moist to prevent the gills from drying up, and thus there is no reason why, in cool and damp weather, the crayfish should not be able to live very well on land, at any rate amongst moist herbage."

Consequently, the explanation that the nymphs breathe through the skin may, perhaps, be dispensed with, when the nymph is out of water, and true aerial breathing substituted. One's only regret is that thus the point would seem to be removed from one of Mrs. A. Gatty's most beautiful "Parables from Nature."

THE EVOLUTION OF SIMPLE SOCIETIES.

By Professor Alfred C. Haddon, M.A., Sc.D., F.R.S.

V.—THE METAMORPHOSIS OF HERDERS INTO TILLERS.

In the article on "The Beginning of Agriculture" it was stated that a powerful constraint is necessary to force pastoral communities into the uncongenial occupation of agriculture. Again closely following M. Demolins I shall briefly describe how this constraint has been exercised upon two very different groups of herders. My French colleague has in his turn drawn upon the observations made on the spot by Le Play, and published in his "Ouvriers Européens," Vol. II., chaps. 1 and 8.

Environment.—The first locality selected for study is the village of Mochmet, which is situated on the eastern slopes of the Ural Mountains between Troitzk and Ekaterineburg, close to the great divide on the upper portion of the valley of Miask. Thus this village is located on the last of the Siberian slopes, and conversely is at the first point of contact with the sedentary populations of Europe. It is inhabited mainly by Bashkirs, who formerly were nomadic pastors, as their brethren still are on the neighbouring steppes.

Two conditions are necessary to enable a people to pass from a pastoral mode of life to cultivation of the soil:—1. The soil must naturally or artificially receive a sufficiently prolonged irrigation. As we have seen, owing to the short season of humidity, grass, practically

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to the exclusion of other vegetation, characterises the steppes; here numerous rivers and forests bear witness to the humidity of the climate. 2. The population must be constrained to become sedentary.

The neighbourhood of pastoral hordes is a permanent source of danger to sedentary peoples. The Russians, like the Romans of old and the French in Algeria with regard to the Arabs, remedy this by forcing the frontier nomads to become sedentary and agriculturalists. This is effected by the system of cantonment. No one is allowed to go beyond his canton on pain of death.

The process of cantoning consists in limiting the range of a horde and even in reducing it to till the soil. This modifies the pastoral life. The families begin to be less independent and self-sufficient. Soon they exchange the excess products of their flocks for domestic utensils and cereals in the great markets of Orenburg, Troitzk, etc. The introduction of cereals into every-day food is a forerunner of more important transformations.

Occupation.—The Bashkirs, as far as possible, retain the pastoral life, as during the five summer months, May to September, they live in tents. The main nourishment of the nomadic herders is furnished by mares' milk, and it is the number of these animals that constitutes a sign of wealth, but their number is greatly reduced.

All pastoral peoples exhibit a repugnance to other occupations. Two examples will suffice to illustrate this disposition. The pastoral mountaineers of the small canton of Uri, in Switzerland, could not be induced, even by high wages, to work at the St. Gothard tunnel, and Italians had to be imported. The Arabs in Algeria exhibit the same dislike to manual labour on the soil. The desire for wealth and the satisfaction of refined wants are not constraining forces in simple societies; they are rather artificial products, created slowly and with difficulty by a more complicated social state. What is natural to man is the love of ease and quietude.

The poorer Bashkirs who are obliged to subsist by agriculture or manufactures, go at least once a week to the tents to partake of the pleasures of kumis and exemption from agricultural toil, as well as for prayer and meditation in the beautiful country where the tents are pitched. How hard it is when winter arrives to descend to the village of Mochmet to be confined to a house and to live a sedentary life.

Work ceases to be attractive and the social conditions more complex. Two classes of family result: (1) the provident and (2) the improvident—*i.e.*, the greater number who have to be directed and maintained by the former. Thus we have an upper class and a lower class, and here we can trace the commencement of inequality among them. Hence the social problem arises of protecting the improvidents against their improvidence. These two classes are clearly marked among the Bashkirs. The one succeeds in maintaining and developing its first attempts at cultivation; the other, after vain attempts, falls back purely and simply to the wandering life of the pastors.

At first a pastoral people does not entirely devote itself to agriculture. The more improvident, as we have seen, live in their old state of life, while even the provident continue to rely as far as possible on the old habit of simple harvesting. The education of the agriculturist is a slow process.

Great variety of treatment is required in the cultivation of diverse plants, and the social consequences of varied tillage are very different from the uniformity impressed on the pastoral art. The Bashkirs employ those plants that necessitate the least amount of trouble and foresight. These are (1) hay for winter consumption, (2) vegetables, and (3) flax and hemp. They demand little time and labour, and all but the last two provide products immediately usable for the direct wants of the family. (1) Hay is the spontaneous production of the grass. (2) The vegetables require only easy work. The soil is abundant, rich, and well watered. The labour is performed by the women. A family possesses only two spades and a hoe, there is no plough. Seven days of work in a year suffices for the cultivation of a garden. They grow potatoes, turnips, carrots, onions and hops. (3) The cultivation of flax and hemp demands only five days' labour of the women, four days of the children and one day of a horse.

Many Bashkirs refuse to cultivate corn, because it gives too much trouble, but they have need of it owing to the diminution in milk. The work of the men occupies only twelve days, which are employed in the transport of the grain and other commodities.

Even this rudimentary cultivation demands more forethought and more resources than the pastoral art; for example, the stabling of the animals in winter and feeding them; the building of stables and barns; the hay must be got in rapidly and be properly preserved and of sufficient quantity to last through the winter. Then there is the cultivation of edible and textile plants.

A fixed house, as opposed to a tent, becomes necessary, fodder cannot be readily transported. Here the difficulties in the way of a fixed house are considerably reduced owing to the abundance of available land, the sufficiency of spontaneous productions, such as wood, etc., and the custom of *heummin*, or communal labour. This is an assemblage called together for a special purpose, such as carting, harvesting, building, and the like, the only reward being a copious feast at the end of the day and a distribution of brandy. This custom is a very widely spread one, and these communal operations form occasions for recreation and feasting. The *heummin* is an important social symptom, as it testifies that owing to cultivation, families, at least for certain works, can no longer as in pastoral societies suffice for themselves. They have to call in strangers, especially in the case of harvest, when on one occasion the provisions for the whole year are garnered. This is the first step along the road that leads to the introduction of hired labourers.

Property.—In the steppes the soil belongs to the community at large, the herder pitches his tents, and his flocks browse the pasture. Proprietorship lasts as short a time as the work. In agricultural communities the duration of work is prolonged. It takes several months, or even a year, before the recompense for the labour is attained. The prolongation of the duration of work necessitates the prolongation of ownership. This is the case with the Bashkirs, who have the least possible love for ownership of the soil. They take the minimum ownership; but, for all that, they remain several years on one spot. They do not annex property, it is the property that seizes and constrains them and which will not let them go. The duration of appropriation grows according to the exigencies of the labour. Among the Bashkirs the commune—still the sole proprietor of the soil—concedes to each family a portion of land for a period of fifteen years. Tacitus has recorded a

very similar state of affairs for the ancient Germans, a mobile people but lightly attached to the soil. He says: "Land proportioned to the number of inhabitants is occupied by the whole community in turn, and afterwards divided among them according to rank. The wide expanse of plains makes the partition easy. They till fresh fields every year, and they have still more land than enough; with the richness and extent of their soil, they do not laboriously exert themselves in planting orchards, inclosing meadows and watering gardens. Corn is the only produce required from the earth."

Landed property tends to become more and more permanent. Le Play says that, among the Bashkirs, the arable lands and the prairies where they gather hay are allocated to the families, and they transmit them from generation to generation with definite limitations. However, the right exercised over this property by the family is more restricted than it is for the proprietors of the west, and still leaves a fairly large part to the right of the community. If portions of the land conceded to the families are not tilled during the space of several years those uncultivated lands revert to the community.

Landed property in becoming fixed is distributed by families, but not every family is capable of owning landed property. Among the Bashkirs the community gives each family a domain of which the greatest part is usually left fallow, because there is not the necessary aptitude for cultivating it. At the expiration of fifteen years the uncultivated land is reabsorbed by the community. The majority of the Bashkirs of Mochmet are in this case—they eliminate landed property from themselves, only the more provident remain proprietors. Thus there is a natural selection.

This return of unutilised landed property guarantees the possession of the soil to those who can cultivate it. The land cannot be alienated or mortgaged. Often even capable cultivators might be tempted to realise on land in order to pay numerous small debts, as happened when the serfs were suddenly put in possession of land in Russia and Hungary. On this occasion the majority of freed serfs were incapable of retaining it, and so a great deal of land fell into the hands of the Jews.

A distinction must be drawn between property in land and the property of the home. Landed proprietors comprise the more provident individuals, the best trained to work, to economy, to the position of masters. It is the race of true small farmers, the men of the country, strongly attached to the land, and who form the solid foundation of society. The proprietors of homes and their immediate dependencies with garden and orchard comprise the less provident individuals only capable of owning a property corresponding to their daily needs.

The Family.—Cultivation of the soil does not necessitate any essential modification of the organisation of the patriarchal family, and it maintains the moral effects of this form of family, the spirit of tradition pushed to routine, respect for pastoral authority, the preeminence of the old men, and social stability or rather immobility.

Certain functions, however, are henceforth fulfilled by agents outside the family; these are (1) religion, (2) the intellectual training, (3) government. In the isolation of the nomadic life these three functions were, like all the others, fulfilled by the patriarch. But these three functions are not essential to the paternal authority, they can be removed without diminishing anything of the essential function of a father, which is the government of the family.

The Bashkirs are Musulmen, and the Mullah of Mochmet performs in the mosque the ceremonies of his religion that relate to the birth, life, and death of his flock and to the sacred days of Islamism. He also acts as adviser, arbitrator, and often as judge. He teaches the young of both sexes, he even renders aid in sickness.

Government.—As to government, three causes contribute to lessen the paternal authority:—

1. The necessity of administrating and allocating the communal ground. This necessity does not exist in the steppe, for grass requires no administration, but in settled communities the land has to be partitioned out. The distribution of land is made by the assembly of the inhabitants, presided over by the Vuiberni, a sort of mayor of the commune. The Vuiberni is, after the Mullah, the richest person in Mochmet: he has four wives, and possesses six mares and four cows.

2. The obligation to construct and maintain the necessary buildings for religion and instruction. This is another consequence of a settled condition of life, and requires the combined action of all the families of the community, and it implies the payment of the instructor.

3. The necessity to provide for the public peace. As families congregate in a limited area misunderstandings arise, and disputes have to be settled by the intervention of a superior authority. Further, the neighbourhood of nomads is a source of perpetual conflicts—all border countries between steppes and cultivated land develop a race of nomad robbers. Each family cannot defend itself against the raiders, hence a public force has to be constituted, which is supported by a levy, according to circumstances, of recruits, horses, or money. A simple form of government regulates the public affairs of the community.

Although the soil is allocated by the Vuiberni the communal forests are under the charge of a Russian official. In Switzerland the forests of each canton are inspected by federal officers, the same obtains in France, otherwise the forests, which really are the accumulated wealth of the community, would fall a prey to the improvident.

Thus the law of property varies according to the nature of the chattels. The land may belong to everybody, cultivated land to provident families, the management of forests only to the most capable or to a stable government.

A study of even a small people may thus illustrate the social transformation due to the sole cause of a substitution of cultivation for pastoral life.

Work becomes hard and exercises restraints. Property is restricted and is possessed by the most provident families. The family is shorn of some of its functions. Special representatives of religion and education are elected. Government arises.

What has produced these great changes? Is it intense cultivation made over large areas? No; it is the most rudimentary of all cultivation—a simple gardening; the growing of a few potatoes, turnips, carrots, and onions!

ASTRONOMY WITHOUT A TELESCOPE.

By E. Walter Maunder, F.R.A.S.

IX.—AURORÆ.

It is an old saying, of the truth of which we are often

reminded by our daily experience, that what is everybody's business is nobody's business. Work which someone is obliged to do, or is paid to do, gets done. Work too which is only open to a few to undertake also generally finds that some of that few will undertake it. But that which is open to everybody and yet to which no one is appointed, nobody driven, hangs fire and is left undone.

To take one example, one of the very earliest achievements of astronomy was to determine the length of the year. This was done long ages ago, earlier than we have any record. But it was a necessary or at any rate a very practical and useful work, and consequently was done at an early epoch. Take again a modern instance —the observation of double stars. This is a work which is by no means within everybody's reach. A powerful telescope, well mounted, clock driven, and furnished with a good micrometer, is the luxury of the few. But in spite of, perhaps we should rather say because of this restriction, double star observation has always found a number of ardent followers. So that, although it is but 120 years since this branch of astronomy took its rise, it has already made a most amazing progress.

On the other hand, the various branches of naked eye astronomy, branches open to every one who had eyes to see and a good atmosphere, have been left almost unworked. The departments of meteoric and variable star astronomy are the only two in which great and substantial progress has been made, and in both cases such progress has been the work of the last few years.

There need therefore be no surprise that the study of auroræ has not yet received the attention which is its due. A certain progress has been made, and it has had some very earnest and able workers, but the "Astronomer without a Telescope" who should take up this subject would find that he was by no means a gleaner in a closely reaped field.

The points which have been established are of great importance. First of all, we know that though, strictly speaking, meteorological phenomena, auroræ have a close astronomical connection. They vary in number as observed in any given locality in accordance with the sunspot cycle. More than that, they are evidently in the closest sympathy with the disturbances which take place in terrestrial magnetism. The present time therefore is not a specially favourable one to attempt their observation in these latitudes, since they are practically non-occurrent in England at the sunspot minimum through one of which we are now passing. Yet just as magnetic storms have their greatest amplitude and occur most frequently near the equinoxes so it is with auroræ, and October is the most prolific month of the year.

Auroral observation demands, beside good eyesight, an observing station remote from the glare of towns and artificial lights. The stories are common enough of fire engines being turned out to quench an aurora, and, on the other hand, it has not seldom happened that a very mundane conflagration has passed muster for a "celestial display." "In the Memoirs of Baron Stockmar an amusing anecdote is related of one Herr von Radowitz, who was given to making the most of easily picked up information. A friend of the Baron's went to an evening party near Frankfort, where he expected to meet Herr von Radowitz. On his way he saw a barn burning, stopped his carriage, assisted the people, and waited till the flames were nearly extinguished. When he arrived at his friend's house he found Herr von Radowitz, who had previously taken the party to the top of the building to see an aurora, dilating on terrestrial magnetism, electricity, and so forth. Radowitz asked Stockmar's friend, 'Have you seen the beautiful Aurora Borealis?' He replied, 'Certainly; I was there myself; it will soon be over.' An explanation followed as to the barn on fire. Radowitz was silent some ten minutes, then he took up his hat, and quietly disappeared."

Granted the suitable position the most important consideration for the student of auroræ to bear in mind is the absolute necessity for keeping as systematic a watch as possible. The general agreement between the cycles of sunspots, of magnetic variation and of auroræ is clearly established, but there are many questions arising as to the connection between their minor fluctuations. Now the observation of the magnetic elements is perfectly continuous. Self-recording magnets are set up at many observatories, and supply us year in and year out with an unbroken register. Our record of the state of the sun's surface is practically continuous also, but from the nature of the case auroræ cannot be presented in the same manner. The chronicle is broken by the intervention of cloudy nights. It is weighted by the difference in length of darkness between winter and summer. Further, it is difficult to express our auroral observations on a perfectly uniform numerical scale. One year may have a poor record, either because auroræ were actually rare, or because the observer was remiss or the weather unfortunate. Another year may present a fallacious appearance of abundance simply because the observer was more diligent or more lucky in the circumstances of his observations. In a word, the accidental errors of the work are large, and it therefore becomes the first duty of the student to keep his own personal part in the matter as systematic and as free from accident as he can.

This is the first essential, and the observer therefore should draw up a scheme for himself for the examination of the sky at certain definite hours, and for certain fixed intervals, to which he should adhere with the greatest possible regularity. There is no need for him to make any great inroad into the ordinary hours of rest, as the meteoric observer must do, or that his watches should be very prolonged. It will be sufficient if they are perfectly regular.

It is much to be desired that auroral observers should be scattered as widely as possible, that we may be able to present not merely the auroral conditions for a single place, but for the entire planet. It has already been discovered that they are most frequent in two zones, one in the northern and one in the southern hemisphere, and that these zones shift their position with the progress of the cycle. In mid-latitudes as in England auroræ are most frequent at the time of the sunspot maximum. They retire polewards as the sunspot frequency declines, and are most frequent in high latitudes at the sunspot minimum. The place of the observer, therefore, is not a matter of indifference. A broken record in England cannot be pieced out by observations in the Shetlands or in Iceland.

But the value of a regular system of observations carried on at a single station for many successive years is very great, and we cannot have too many observers in the field.

After the mere fact of an auroral display has been noted, its duration and its average brightness are points to record. The duration, of course, is a simple matter; the brightness is more difficult, but a careful watch upon

the auroræ of a rich year will enable the observer to draw out a rough scale for himself, which will satisfy the possibilities of the case.

An important detail in auroral work is the fixing of the position of some specially bright point from two or three fairly distant stations with a view to the determination of its height. This can obviously be best done by reference to the stars if many of these are visible at the time. It would, however, be well to have at hand some rough and ready means for obtaining the altitude and azimuth of any given point, and for this it would be easy to make a sort of rough wooden theodolite or altazimuth with a bar carrying a big easily seen pair of sights upon it instead of the telescope. As the auroral flashes come and go so quickly the time of any such determination must be taken with jealous exactness.

The value of having some means always at hand, however rough, for determining the position of an auroral beam, together with the need for exactness in giving the time of the observation, was well illustrated by the remarkable auroral beam of 1882, November 17. A great sunspot, the largest visible for eleven years, was nearing the central meridian of the solar disk. The magnet, which had been uneasy from the time of the first appearance of the spot at the east limb, began to be seized with the most violent convulsions about two hours before noon on the 17th, the disturbance lasting till 6 o'clock the following morning. "Strong earth currents were also observed at all the times of magnetic disturbance, varying in magnitude with the intensity of the magnetic changes, and the most violent electric storm recorded for more than thirty years swept over Europe and America." In sympathy with these manifestations a superb auroral display was witnessed on the evening of the 17th, but by far the most unique and striking phenomenon occurred "at about 6 p.m., when a bright beam of light rose from the eastern horizon and passed majestically across the sky in much the same manner as any ordinary celestial body might do, but with several hundred times their rapidity." Some twenty-six observations of the phenomenon were collected together by Mr. Rand Capron, but most of these were very incomplete, and their discussion was therefore attended with much difficulty, yet imperfect as the observations were they seemed to show with considerable probability that the height of the beam was 133 miles, and its speed about 10 miles per second. The direction of its flight was from east to west, magnetic not geographical. Had three or four of the observers but possessed some simple means for measuring the height of the beam at its culmination and the azimuths of its rising and setting, the precision of these conclusions would have been greatly increased.

The same charts that are useful for meteor observations may very conveniently be used for auroræ, the positions of the streamers or of the auroral crown being sketched in with reference to the stars. In all the work the first thing to be aimed at is to make the record as definite as possible. It is here that the difficulty of auroral observation is most felt. They are beautiful and impressive as spectacles, and the student will need no instruction in the preparation of his general descriptions. But to pick out the particular phenomena to which the desirable amount of definiteness can be ascribed will require practice.

From time to time curious beams of light are seen in the sky the exact nature of which it is difficult to determine. Thus on March 4, 1896, a curious light was seen stretching up from the horizon towards the Pleiades which some observers were inclined to regard as auroral, some as the Zodiacal Light, and some actually regarded it as being cometary. The fact that an unmistakable aurora was seen the same evening pointed strongly in favour of the auroral theory. On the other hand, as its direction coincided nearly if not precisely with that of the axis of the Zodiacal Light, and as similar beams have been seen in the same position on other occasions, the question cannot be regarded as absolutely decided. It would be a matter of the highest interest could it be shown that certain definite regions of the heavens were subject to recurrent flashes, and a careful collation of observations made at widely separated stations would soon settle as to whether we should regard them as auroral or zodiacal, and could not fail to increase our comprehension of one or the other phenomenon.

DARK MARKINGS IN THE SOLAR CORONA.

By W. H. Wesley, F.R.A.S.

Everyone who has examined a series of photographs of total solar eclipses is familiar with dark rifts or gaps in the corona. Most conspicuous at times of sun-spot minimum are the polar rifts, which at such periods open widely and occupy a considerable portion of the sun's polar regions. Rifts, more or less dark, also occur in other parts of the corona, sometimes sharply cutting into the densest portions. There can be no doubt that these rifts are merely interspaces between coronal rays. They show the extremely irregular manner in which the corona is distributed over the sun's surface. In view of the fact that the corona, whatever it may be, is not flat, as it appears during an eclipse, but is an object possessing three dimensions, it is obvious that a sharply defined rift, cutting into a dense portion of the corona, and traceable to the sun's limb, represents a gap of most singular form.

But striking as are these coronal rifts, there is a still more interesting class of dark markings that in many cases cannot be explained as mere interspaces among the bright rays. Unlike the ordinary rifts these dark markings are only occasionally seen. A close examination of the original negatives is often necessary to detect them, and as a rule they are lost in any photographic reproduction.

The first instance of their occurrence of which I know was in 1871. On the eastern side of the corona, in the

Fig. 1.—Diagram of Markings on the Corona of 1871.

equatorial region, there appears on the photographs a small dark spot about 9' from the sun's limb. It does

not occur near the crossing of any coronal rays, in which situation such an object might possibly be simply an interspace, but appears to encroach on bright rays. Morever, it is the centre of three arcs of circles, concave towards the sun, with radii of 3', 6', and 10' respectively, the middle one being fairly strong, while the others are excessively faint. These singular appearances were thought by Mr. Ranyard to indicate the existence of a comet, showing as a dark object on the background of the corona; but as to this I pass no opinion. If it was a comet, its appearance was unique, for the comet on the negatives of the 1882 eclipse, and the much fainter one found by Schaeberle on his photographs of the eclipse of 1893, were both bright objects. But in any case it seems impossible that the dark spot and concentric arcs on the corona of 1871 can be interspaces between rays, for the arcs actually cut through several coronal rays almost at right angles, partially obliterating them. The whole appearance is extremely difficult to see, but I have traced the dark spot and the arcs on several negatives of two different series, and am certain of their existence.

The next example of dark markings occurred in the corona of 1896, the eastern side of which exhibited

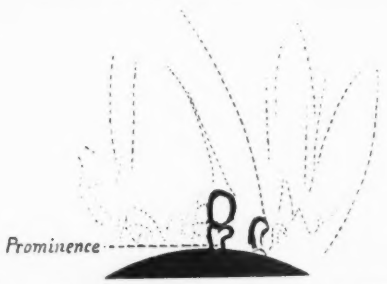


Fig. 2.—Diagram of Markings on the Corona of 1896.

features of a different kind to any I have examined. I will, however, refer only to those bearing on the subject in hand. Almost at the sun's equator is a bright double-headed prominence, which is distinctly *outlined* by a strong dark line, following all its contours. A little to the north is a small hooked coronal ray about 2½' high, apparently springing from a small prominence. This ray is also outlined in the same manner. But by far the most extraordinary appearance is that of a dark roughly elliptical ring, about 2½' in its longer axis, which stands on the top of the bright prominence. From the summit of the ring springs a fairly bright, fine ray, which would probably be traceable further down towards the limb but that its base seems cut off by the ring. There are many other dark streaks in this part of the corona, but we may confine our attention to the most striking features—the outline to the prominence and the ring. They are clearly seen on at least two of the negatives taken by Mr. Shackleton in Sir G. Baden-Powell's expedition to Nova Zembla, and, unlike the markings on the corona of 1871, they are quite easy to see under suitable conditions of illumination. A little reflection will convince anyone that the *outline* can be due to no known photographic effect. The image of a bright object (such as a bright prominence) may spread itself on the plate, and thus appear enlarged, or it might conceivably be surrounded by a halation ring, though I feel sure that the exposures during eclipses have never been nearly sufficient to cause such a ring round a prominence. But neither of these well-known photographic effects will explain the appearance in the least. Had an observer *drawn* the dark outline surrounding the bright prominence, we should have concluded at once that it was a mere effect of contrast, but the camera is fortunately not influenced by contrast. Is it possible that the prominence had edges enormously brighter than its centre, so that the dark outline is a phenomenon of reversal? This is improbable in the last degree, in view of the small aperture of the instrument and its considerable focal length; there was also slight hazy cloud, and the plates generally show no signs whatever of over exposure; their definition is admirable. There are many instances of reversal of the images of prominences in 1882, 1893, 1898, and 1900. In 1882 their centres were reversed, but there has been no case of reversal of their edges. Besides, the hooked coronal ray is also outlined, and that was certainly not bright enough for reversal, so this explanation breaks down. Then we have the elliptical ring, for which there seems absolutely no explanation, except that it is really a dark marking of some kind. It is surely absurd to suggest that it can be a mere space between coronal rays; we should have to imagine a tunnel cut through the body of the corona, directed precisely in the line of sight, and a plug of coronal matter lying along the centre of that tunnel but not touching its sides.

It will be seen that in the above cases the argument for the objective existence of dark markings is based upon the form and character of the markings, and not upon their actual darkness. Neither in 1871 nor in 1896 are they nearly as dark as the sky; but have we any instances of markings in the corona that are actually *darker* than the sky? If so, it appears to me that their objective existence is proved beyond a doubt. I believe we have such evidence, but here great caution is required, for although the camera is, as has been said, unaffected by contrast, the eye which examines the photographs is much affected by it, and we may be very easily deceived.

I have before me two negatives of the eclipse of 1898, taken by Mr. F. Bacon at Buxar, near Benares; they are rather over-developed, the lower portions of the

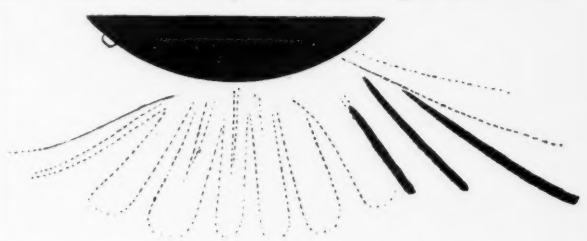


Fig. 3.—Diagram of Markings on the Corona of 1898.

corona are extremely dense and opaque, but the focus is excellent, and the outer portions well shown. The scale is a little over half an inch for the moon's diameter. On first looking at these I was struck by the unusual sharpness of definition of some of the rays of the great southern rift; but on more careful examination with various illuminations it seemed possible that this sharp definition is due to nothing less than to two or more fine dark rays (of course bright on the negative) lying between some of the bright polar rays near the western boundary of the polar rift. There is nothing un-

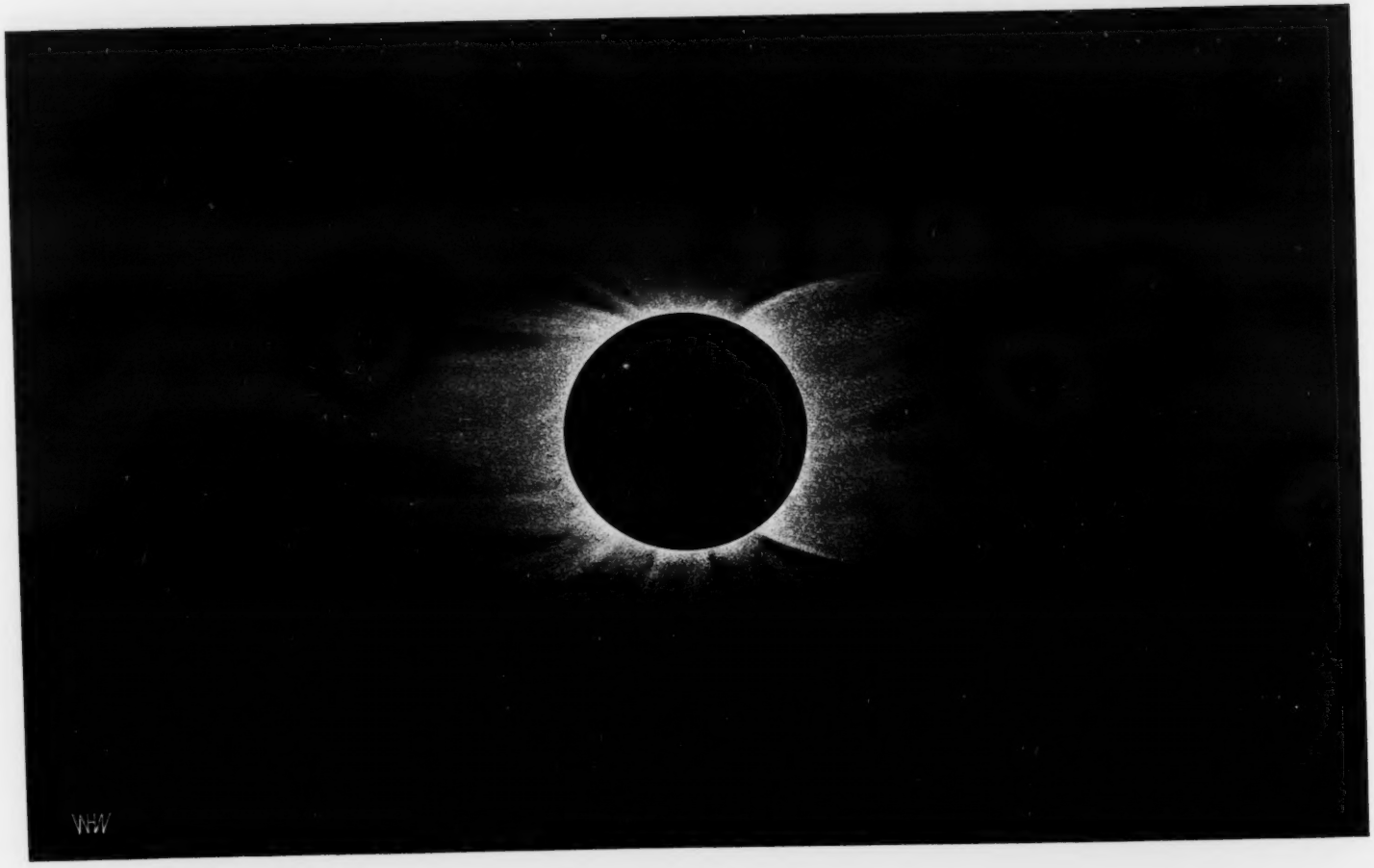
XUM

XUM

XUM

NORTH.

EAST.



WEST.

SOUTH.

THE CORONA OF 1900.

Drawn by Mr. W. H. WESLEY from Mr. MAUNDER'S Photographs.

XUM

usual or extraordinary in the position of these dark rays. I at first considered them to be merely spaces between the ordinary polar rays, but I now think that they are slightly darker than the sky. The development has been carried far enough for the light of the sky to impress itself on the plates; but for this fact the markings would appear simply as interspaces, but on these plates I think I can just see the ends of the rays, terminating at about two-thirds of a lunar diameter from the limb. They cannot be traced to the limb, as they are lost among the mass of bright rays, and they are lost in long exposure negatives. These markings are far more difficult to see than those in 1896, but if they are, as I think, darker than the sky, we seem to have taken a considerable step towards proving their objective existence.

We now come to the negatives taken by Mr. Maunder at Algiers during the eclipse of May last. On two negatives taken on Sandell plates with very long exposures, and on a series of negatives exposed by Miss Maunder with ½ sec. exposures in a stationary camera, are certain dark streaks of much the same character as those of 1898, but unlike these, they are most easily seen; in fact on some of the plates they strike the eye at once. One of them forms a sharp boundary to the northern edge of the western equatorial streamer, and one bounds in the same manner its southern edge, while another radiates from the limb near the centre of the great southern rift; there are several others that may be suspected. The only point in doubt is whether they are unusually definite spaces or rifts between bright rays, only seeming dark by contrast, or whether they are actually darker than the sky. If they are darker than the sky we seem forced to admit that they are real, however impossible it may be to offer any physical explanation for their existence. We cannot isolate these fine, narrow dark streaks, so as to avoid the effect of contrast. They are visible on all the six plates of the short exposure series, and the dark markings forming the north and south boundaries of the western portion of the corona are very strikingly shown on the long exposure negatives. These dark rays bounding the coronal extension are extremely remarkable, and it seems impossible to regard them as effects of contrast. For while on the one side they are each bounded by the edge of the coronal streamer, there is apparently no ray bounding them on the other side, and they appear to extend beyond the coronal streamer itself. If this is so, they are obviously darker than the sky, or the faint nearly uniform light which forms their background.* The dark marking bounding the southern edge of the western coronal extension is the most conspicuous.

The narrow, slightly curved dark ray near the centre of the southern rift, is well shown on the short exposure negatives. It has a distinct termination at a distance of about half a lunar diameter from the limb—a termination in fact more definite than those of the bright coronal rays. It seems decidedly darker than its background of sky or faint coronal light. If this marking is merely a rift, or interspace, it must be a rift *closed at its outer extremity*, which appears a most improbable supposition.

I am quite unable to offer any explanation of such features as these, but I think we cannot resist the evidence for their reality. As Mr. Maunder has said, they must be caused "by the interposition of actual dark absorbing matter between ourselves and the general diffused coronal glow"; so that the corona appears to be "not wholly an emission, but partly an absorption effect." The nearest analogy to them are the thick rays in the prominences to which Trouvelot drew attention, and which I believe Mr. Evershed has confirmed.

I have just examined some excellent negatives taken by Miss Bacon at Wadesborough, U.S.A., which clearly show the dark markings visible on Mr. Maunder's plates.

[The eight photographs of the 1900 eclipse to which Mr. Wesley refers in the above paper were as follows:—Two taken with a Dallmeyer stigmatic lens, 1½ inch aperture and 9 inches focal length, on Sandell triple coated plates, and six with a 4 inch lens, presented to the British Astronomical Association by Mr. G. E. Niblett, of the Royal Observatory, Greenwich. Focal length, 34 inches. Plates — Imperial, Extra rapid Ordinary, and Fine grain Ordinary.—E. Walter Maunder.]

* It is probable, as Mr. Maunder has pointed out (Knowledge, August, 1900), that there is a considerable amount of diffused coronal light beyond the limits of the detailed corona. This appears to be borne out by Prof. Turner's photometric measures of the negatives of the eclipse of 1893.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

ASTROLOGY.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—Referring to your Editorial note to my letter in the September number of Knowledge, permit me to express my opinion that there is something to examine in astrology, and that though it is possible that astrologers were and are self-deceived, they are most decidedly not impostors. They do not go on blindly accepting the old teachings, but do their best to rectify and allow for any irregularities they may discover. "Astrologers can neither tell when or how the special 'influences' supposed to reside in each individual 'planet' or 'house' were determined, nor give the observations upon which primitive astrology was based" because thousands of years have elapsed since these data were established, and we have, like astronomers, no traditions or records to guide us, but it is only fair to assume that the early star-gazers were led to compare the planetary motions with events until the present system was formulated, possibly in Sumers-Akkadia, Hindustan, or Egypt, who can say?

You say in your remarks "The ancients recognised but seven planets, whereas there are—according to modern astrologers—nine. That is to say, in the opinion of the ancients Uranus and Neptune had no influence, for they never detected anything wrong in their calculations, as they should have done if these planets were really potent." It cannot be denied that modern astrologers do ascribe influences to Uranus and Neptune. They, however, agree that the influence of Neptune is reduced to almost *nil* by his great distance, and that Uranus only affects when in positions astrologically powerful for a similar reason. It is true, however, that in some instances, when nativities have happened at these periods at a time when the existence of this planet was unknown, the astrologer has found his predictions to a certain extent falsified in subsequent events, but these cases are exceptional. On the whole the ancients could prog-

nosticate very satisfactorily without having any knowledge of Uranus, as his influence is only very obvious on rare occasions, and most probably the astrologer would at these times attribute his failures to irregularities or mistakes in his calculations, or to some slight variation in the planetary influences.

The power ascribed to Uranus has been arrived at by the carefully rendered judgment of the leading astrologers upon the aggregate observations and comparisons of the students of this science. Astrologers cannot tell whether there are planets beyond Neptune for the simple reason that their enormous distance would render them of none effect, if existing, and if there are any within Mercury's orbit they are too small to have any effect.

It may be asked if Uranus affects so little why should not Saturn have considerably less influence than is astrologically ascribed to it. To this it can be said that Saturn is much greater in mass and nearer in distance, and these are facts which must be considered, as the influence does "vary directly as the mass of the acting body, and inversely as the square of the distance."

240, Holloway Road, N., B. Chatley.
September 5, 1900.

[Mr. Chatley writes so temperately that although the subject of astrology seems to me, except as a matter of folk-lore, to be one of utter worthlessness, I feel bound to briefly reply to him. I would not have him suppose that I consider all astrologers necessarily conscious impostors. Astrology itself is certainly a fraud, but many of its followers, in the present as in the past, have no doubt been perfectly honest.

Mr. Chatley says that the astrological influence of the planets does vary directly as the mass of the acting body and inversely as the square of the distance. Here he is distinctly at variance with all ancient astrologers, and I fancy with the great majority of modern ones. The masses of the planets have only been determined within the last 200 years. Their relative distances were of course known earlier, but neither distances nor masses enter into the construction of ancient horoscopes, and are certainly very often if not always omitted from modern ones.

Mr. Chatley has probably overlooked the fact that if it be true that astrological influence be subject to the same law as gravitation, then the sun is some five million times as potent as Mercury, and the moon is thirty thousand times; Jupiter one hundred and eighty times; Venus and Saturn only twelve and fifteen times. Mars will average as weaker than Mercury, and will have almost the same mean potency as Uranus; but though Mars will occasionally come into very effective positions for a considerable part of its orbit it will rank much lower than Uranus, and often be feebler than Neptune. The influence of Uranus, so far from being occasionally effective, will be very evenly steady.

I think then it is abundantly clear that the law of gravitation finds no place in astrology. Yet if we assume that the influence of the planets is irrespective both of mass and distance we shall find ourselves confronted by a more serious difficulty still.

It is, however, sufficient to take Mr. Chatley's own admission that the original observations, if there ever were any such, upon which the rules of astrology were based, have perished. Those rules, therefore, are accepted now adays simply in blind unreasoning faith, and therefore "astronomers do not care to waste time on an examination into astrology, for the reason that there is nothing in it to examine."—E. Walter Maunder.]

TO THE EDITORS OF KNOWLEDGE.

Sirs,—Mr. E. W. Maunder does not appear to have got beyond the five senses in his criticism of Astrology, and I am quite certain from his remarks that he has never given the subject any serious study. The TRUE astrologer believes that the sun is the body of the Logos of this solar system, "in Him we live and move, and have our being." The planets are his angels, being modifications in the consciousness of the Logos. Astrology explains the harmony of the spheres, and a correct knowledge of its teachings must elevate and raise every individual consciousness.

It is very easy to pull down, but a far more difficult task to build up. If anyone chooses to call Jupiter malign, and Saturn benefic, as Mr. Maunder suggests, I will contradict him, and, what is more, prove it. You can settle any dispute with regard to the truth of astrology by accepting a test case, and publishing the result in Knowledge. But to convince a prejudiced person against his will is, I fear, a hopeless task, but I am willing to do all I can to prove that astrology is true and not false. Alan Leo,
Editor of *Modern Astrology*.

9, Lyncroft Gardens,
West Hampstead, London, N.W.

[I did not expect so prompt and authoritative an acknowledgment that I was right in stating that astrology was only a survival of paganism. Mr. Chatley will see that Mr. Leo conclusively answers him. The physical sciences deal simply with the objects known to us by the five senses. If he is to be an astrologer on Mr. Leo's lines, he must leave the evidence of his senses behind. To such a demand men of science, and Knowledge in their name, can pay no regard.
E. Walter Maunder.]

THE ZODIACAL LIGHT IN RELATION TO THE CORONA.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—As an amateur who in a humble way takes delight in the study of "Astronomy Without a Telescope," I read with much pleasure Mr. Maunder s article on the Zodiacal Light, and it occurred to me that this light may arise from the same cause and partake of the same nature as the mysterious light that plays about the moon's edges during a solar eclipse. This may seem bold for an amateur to suggest, but the thought carries reason with it when we reflect that every sunset is an eclipse of the sun—to the observer—that is to say, every time the sun sinks out of view the observer sees it being gradually eclipsed by the rising horizon; and every morning he sees the sun rise into view he sees the eclipse passing off.

Early astronomers held the opinion that the corona was due to the solar beams being refracted by the atmosphere of the moon, but modern investigators tell us the moon is devoid of atmosphere. In this case, by the way, why is the moon not battered out of existence by comets, meteors, and the various fiery fragments that scourge the heavens, seeing that the earth is protected by an atmosphere; and by what means (if these celestial batteries have been falling on its surface for countless ages) has it not become overweighted, lost its equilibrium, and fallen from its high sphere into the lap of mother earth? But admitting the moon to have no atmosphere; when we know that light is capable of being reflected from any body whatsoever, no matter

how solid or rugged its substance may be, it is no great stretch of imagination to suppose that the solar beams, impinging on the rugged surface of the moon, will be broken up and dispersed in all directions, as the sea waves are broken up and scattered in foam when they dash against a rock-bound shore. This theory is not confuted, as may seem at first sight, by the appearance of the moon's dark body moving across the luminous area. We take it for granted that the rays of the sun in course of an eclipse are at all times focussed upon a given point of the moon's sphere, that point being in a direct line between the eye of the observer and the centre of the sun, and that said rays are dispersed within a given area describing a circle. Now, as the central point of the moon's sphere approaches coincidence with the central point of the solar orb, the increasing diameter of the moon will encroach on the circle of visible dispersion, and seem to pass across the face of the illuminated area. The extent of this luminous circle of dispersed light will vary—to the observer—and might be expected to increase in brilliance and in area in proportion to the decrease of direct light from the sun, until when complete coincidence takes place and darkness lies over the land a more or less concentric ring of light will result, extending far beyond the borders of the moon.

With reference to the analogy between this phenomenon and the Zodiacal Light it may be observed that before and immediately after the sun sinks below the horizon, to a beholder its rays are refracted solely by the earth's atmosphere; and cloud and sky assume an endless variety of beautiful and evanescent hues; but as the earth revolves on its axis, the beholder changes his position relative to the direction of the solar rays, which form an ever-widening angle with the observer's line of vision. This being so, is it not just possible that given a certain position for sun, earth, and beholder, the reflected light of earth and atmosphere together are projected upwards in the direction of the zenith, and become visible from the observer's standpoint after the darkness is sufficiently dense to show it up? This earth-shine anyone can see with naked eyes by examining a new moon. A Country Lad.

Galston, Ayrshire.

[A friend of ours having been shown the anatomy of a caterpillar under a microscope, exclaimed in wonder, "I never knew that a caterpillar had organs; I always thought it was only skin and squash." There might have been something in "A Country Lad's" suggestion, if either the Corona or the Zodiacal Light were mere shapeless glares of light. A single glance at the actual Corona, or the comparison of a few good photographs, would convince "A Country Lad" that it was no more an amorphous "squash" than a caterpillar is, but that it possessed a real and definite structure; a structure quite independent of "the rugged surface of the moon." It is a real entity; not a mere diffusion or refraction effect. So the Zodiacal Light, although much less definite, proves by the character of its motion amongst the stars that it too has an actual objective existence.

[E. Walter Maunder.]

"THE 100 BRIGHTEST STARS."

TO THE EDITORS OF KNOWLEDGE.

Sirs,—In the article on the "Hundred Brightest Stars" there are several points I should like to ask about. I will number them.

1. No. 7 is given as "Rigel (α Orionis)" and No. 11 as "α Orionis." If the second "α Orionis" is Betelgeux it is given as "β Orionis" in my chart.

2. Should not the note on No. 2 read "does not rise"?

3. The note numbered 66 looks as though it belonged to Algol, 68.

4. In the list there does not seem to be a sharp line between the magnitudes as given on my little chart. Can you say on what plan or on whose authority these "rough" charts (my own is Philips' Star Maps) mark the magnitudes? L. Cuthbertson.

32, Sparsholt Road, Crouch Hill, N.,
September 12, 1900.

[1. No. 7, Rigel (α Orionis), is a misprint for β Orionis.
2. Yes.
3. 66 is a mistake and should read 68 (Algol).
4. The magnitudes shown on popular star maps are always more or less unreliable.—J. E. Gore.]

OCCULTATION OF SATURN ON SEPTEMBER 3.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—This phenomenon was witnessed here under the best of atmospheric conditions. I turned a 4-inch Cooke refractor on the moon at 6h. 35m., and with a power of 65 immediately saw Saturn a little east of the dark limb and exceedingly faint. Increasing the power to 235 I calculated the approach of the two bodies, and then the gradual encroachment of the moon's dark periphery upon the W. ansa, the ball, and finally the E ansa. The effect was very picturesque and novel during the 110 seconds over which the disappearance extended. This interval applies to the time elapsing from the first observed flattening of the ring to complete occultation.

At reappearance the moon was much brighter in the darker sky, and the relative brilliancy of Saturn and the limb of our satellite afforded a notable difference. When the outer section of the ring emerged it was only just perceptible, being nearly obliterated by the intensity of the light from objects on the lunar margin. The reappearance of the planet occupied a shorter period than the disappearance, as it emerged at a different angle relatively to the major axis of the rings. When quite free the comparison of tint between the planet and moon was very interesting, the feeble leaden line of Saturn being in striking contrast with the vivid lustre of our satellite.

As the ball of Saturn was emerging from occultation I looked for a dusky band fringing that part of the moon's edge projected on the planet, but no such appearance could be discerned. A feature of this kind seems to have been occasionally noticed on Jupiter during occultation of that planet.

The times of first and last contact of the outer edge of Saturn's ring with the moon were very roughly noted by my watch, as 7h. 12½m. and 8h. 10m. About 15 minutes after the reappearance Saturn became distinctly visible to the naked eye near the S.W. limb of the moon. W. F. Denning.

Bishopston, Bristol,
1900, September 6th.

JUPITER.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—I regret that in my drawings of Jupiter, published in the September number of Knowledge, the planet was shown with a circular instead of an oblate

disc. My original figures were correct, but in the wash-copies made from them at your office for purposes of reproduction the shape was altered, and when examining the proofs I failed to notice the change, my attention being riveted on the markings. The responsibility for the mistake rests entirely with me, and no doubt it would have been rectified but for the very ill-health from which I suffered, and which made work very difficult for me at about the time I had the proofs. The shape of the planet as represented does not affect the general accuracy of the details shown, but the object ought to have been delineated in his natural figure, and I have thought it worth while to make these few remarks in explanation.

On September 3 I observed Jupiter with a 4 inch Cooke refractor, power 235, and found the hollow in the great southern equatorial belt, north of the red spot central at 7h. 10m., so the longitude of this feature was 44°.4, for it followed the zero meridian (system II.) of Mr. Crommelin's ephemerides 1h. 13.4m.

Bishopston, Bristol, W. F. Denning.
1900, September 6th.

Science Notes.

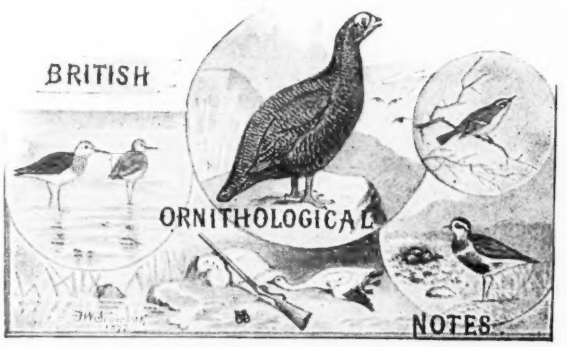
Among the new committees appointed by the British Association at Bradford is one to assist Mr. Vaughan Cornish in his investigation of terrestrial surface waves and wave-like surfaces. It will be remembered that Mr. Cornish contributed a series of articles on "Waves" to these columns in 1896, and he has lately received the "Gill Memorial" for his work in connection with the subject.

The following awards at the Paris Exhibition were made to British Scientific and Photographic Instrument Makers:—James J. Hicks, London, two gold, two silver, and four silver to employees; Cambridge Scientific Instrument Company, Limited, Cambridge, grand prix and silver—one gold and one silver to employees; Ross, Limited, London, grand prix; James White, Glasgow, grand prix; Negretti & Zambra, London, two gold; W. Watson & Sons, London, two gold; Newman & Guardia, Limited, London, gold; J. H. Dallmeyer, Limited, London, gold; Crompton & Company, Limited, London, gold; Kodak, Limited, London, grand prix; also to J. Defries & Sons, London, 2 grands prix; Smith-Premier Typewriter Company, London, grand prix.

Obituary.

We regret to record the death, on the 31st August, of Sir John Bennet Lawes, Bart., D.C.L., LL.D., F.R.S., our pioneer of scientific agriculture. He was born at Rothamsted in the year 1814, and educated at Eton and Oxford. At an early period of his life he succeeded to the family estates, and commenced the series of experiments which have since made him world famous. He discovered the value of bones for fertilizing the soil, but the process of breaking these up was a laborious one, and the fragments were long in being absorbed by the soil. In 1842, however, after many experiments in the field, a patent was taken out for treating mineral phosphates with sulphuric acid, and a small industry was commenced at Harpenden. The success of this undertaking led Sir John to enlarge the manufactory, and a place was selected at Barking. After many years of prosperity the whole business was sold for £300,000, thus testifying to the enormous value of artificial manures as fertilisers of the soil. In 1843, Dr. (now Sir) Henry Gilbert became associated with Sir John Lawes, and these two worked together for upwards of fifty years. It is impossible to indicate here the vast amount of work done by Sir John and his colleague, but the results of the investigations would form a complete history of scientific agriculture during the last half century. The memoirs published by these experimenters from the year 1847 onwards number 130, and include the results of a great many classical investigations on many such questions as wheat production, beet sugar manufacture, and the sources of the nitrogen of vegetation. The late Sir John was elected Vice-President of the Royal Agricultural Society in 1878, and a trustee in 1891; was elected a Fellow of the Royal Society in 1854, while in 1882 the Queen created him a baronet.

It is with great regret that we learn of the death, in San Francisco, on August 12th, of James Edward Keeler, A.B., Sc.D., Director of the Lick Observatory and Astronomer.



Conducted by Harry F. Witherby, F.Z.S., M.B.O.U.

Re-introduction of the Great Bustard.—Whether the re-introduction of the Great Bustard in England will be a successful experiment or not it is at all events a most interesting one. Several Great Bustards have been imported and liberated on the borders of the Norfolk fens. "This effort is due," Lord Walsingham informs us, "to the public spirit of an English gentleman resident abroad." The introduction of creatures in a wild state into a country altogether foreign to them is from every point of view deplorable, but we shall all look forward to the success of this experiment to re-introduce the Great Bustard—once the pride of our indigenous avifauna.

The success of the experiment depends we are afraid in a large measure to the good fortune of the birds themselves.

How ever much may be done, and we are glad to say that much has been done, in publishing the facts about these birds, what will prevent their destruction if once they come within easy range of the ignorant villain who goes out to kill, no matter how, or what, as long as he can safely boast of it?

Let us hope that these bustards from a sunnier clime, but we are afraid no less barbarous country than ours, are amongst the wiliest of their crafty race, and will thus survive. We can hardly expect them to increase greatly, and become what they were a hundred years ago, for since then railways, roads, houses, trees and

hedges, and a hundred minor things have grown up to bar their way and terrify their wild nature, where once stretched the great wastes and rolling plains they loved so well.

Great Crested Grebes in Richmond Park. (*The Field*, August 18th, p. 298.) Mr. W. R. Read records the interesting fact that for the second year in succession a pair of Great Crested Grebes have hatched out two young ones in Richmond Park.

A Short History of the Bearded Titmouse. By J. H. Gurney. (*Zoologist*, August, 1900, pp. 358 - 374.) This is an interesting account of the Bearded Titmouse, which is reduced in numbers in England to a mere remnant (although we are glad to say now an increasing remnant), confined to the Norfolk Broads. The author divides his account into the following heads: Distribution, increasing scarceness, habits, nidification, former breeding area, etc. Additional notes appear in the *Zoologist* for September, 1900, pp. 422 and 423.

A Visit to Lough Erne in Search of the Sandwich Tern. By Robert Warren. (*Irish Nat.*, September, 1900, pp. 220—223.) This is an account of the birds observed breeding about Lough Erne, and establishes the fact that the Sandwich Tern nests there. Hitherto the only known nesting place of this bird in Ireland was near Ballina, in County Mayo.

Notices of Books.

"Researches into the Origin of the Primitive Constellations of the Greeks, Phœnicians, and Babylonians." By Robert Brown, junior, F.S.A., etc., etc. Vol. II. (Williams and Norgate.) 10s. 6d. Just a year ago we reviewed the first volume of Mr. Brown's work on the Primitive Constellations, and it is with much pleasure that we note its continuance in the second and concluding volume. The second volume is in many ways an improvement on the first. Important though the first volume was, as a serious and practically a new investigation into the history and origin of the constellation figures, this volume, which is concerned entirely with the Euphratean star records, is more important and takes us into ground more entirely virgin still. Further, some of the faults which disfigured the first volume are less felt or have been corrected in the second; there is less reason to complain of those vain repetitions which led us before to think that Mr. Brown had become so enamoured of the principle of reduplication in the Zodiac as to conclude that there could not be too much of it in the pages of his books. Though the subject is newer and more difficult than in the preceding volume, Mr. Brown has handled it more clearly and invested it with greater attractiveness. The restoration of the Euphratean planisphere from three small fragments, which forms the subject of chapter IX., is of particular interest. The chapter on "Constellation Subjects in Euphratean Art" would be more convincing if it were not for the manifest assumption on Mr. Brown's part that any object, no matter how familiar, that the Euphrateans sculptured or engraved must necessarily be constellational if it chanced to be amongst the objects which they had chosen for the constellation forms. In the "Tablet of the Thirty Stars" there is a good deal that we find unconvincing. It is difficult to suppose that the original lunar zodiac, no doubt far earlier than the solar one, can have begun with the group σ^2 Alpha Aquarii. Chapter XIII., on the Celestial Equator of Aratos, deals with a subject which Mr. Brown has already treated fully elsewhere, but its great importance in the present connection fully justifies him in bringing it forward again. We note, too, with pleasure his very pregnant suggestion that the constellations probably began with the choice of single stars or of small striking groups; other stars being selected later as they happened to lie most suitably for connection with the original idea. He justly and strongly repudiates the suggestion that the natural configuration of the stars suggested the constellation figures. The idea has had some good names to back it, but a very little direct acquaintanceship with the appearance of the heavens is sufficient to disabuse any impartial observer.

When we come to the question, however, of the origin of the constellation forms, we find a grievous inconsistency in Mr. Brown's position. He cannot make up his mind as to whether the Zodiac took its origin when Aries or when Taurus was the equinoctial sign. He tells us indeed explicitly in more than one passage that the latter was the case; he assumes in a hundred that the former was. Both cannot be true. If he could but steadily lay hold of the fact, which is certainly astronomically established, that the constellations were originally mapped out, possibly in the Euphratean valley, but far north of Babylon, and many centuries before the equinox had entered Aries, it would cause him indeed to revise very much of what he has written, but its value would be indefinitely increased. The bearing of this fact on the solar myth is most important; it teaches us that the sun was not first personified as a Ram and the constellation then designed to accord with it, but that the constellation first received the name and figure of the Ram, and the sun derived its personification from the star group. We trust that Mr. Brown may be persuaded to provide himself with a good precessional globe, and setting it for about 3000 B.C., to go over the ground again, checking every conclusion by its aid. We have no doubt that it will materially modify his views in many details. Even as it is, we assuredly owe Mr. Brown a very heavy debt for the industry and ability with which he has pushed his enquiries into a region previously so entirely unexplored, and yet of such intense interest to all who concern themselves with the beginnings of the oldest and grandest of the sciences.

"Inorganic Evolution as Studied by Spectrum Analysis." By Sir Norman Lockyer, K.C.B., F.R.S. (Macmillan.) 4s. net. This volume may be considered as a sequel to the three works published in the preceding thirteen years—"Chemistry of the Sun," "The Meteoritic Hypothesis," and "The Sun's Place in Nature." Its purpose is to gather together and focus the evidence presented in the three former volumes of the dissociation of those substances which we are accustomed to regard as elementary, and the entire array of observations and theories presented in the whole collection are regarded as a contribution to the study of the evolution of those elements. It is clear, therefore, that the book is one dealing with a subject of the highest importance, and it should be said at once that of the four volumes of the series it is by far the best.

The earlier chapters dealing with the first principles of spectroscopy are admirably clear, so clear as to give rise to the unkind suspicion when Sir Norman writes obscurely—and no one can surpass him in this respect at times—that either he has then no definite idea of what he wishes to say, or else no very strong desire that he should be understood. So far, too, as the present work summarizes the conclusions of the three earlier volumes, we find a considerable increase in precision.

As to the theory here put forward, that of the growth of the elements themselves, it is one of which it is very easy to vaguely formulate. It has been done repeatedly by men who are justly regarded as paradoxers as well as by some of the very leaders of science. Prout's Law, Mendeléef's Periodic Law, were quite sufficient to suggest it to any imaginative mind. But the working out in detail is a very different business, and to discuss adequately the details here given would require as much space as the book itself. Leaving the plausibility, therefore, of the theory entirely on one side, it is sufficient to say here that Sir Norman Lockyer gives a clearer account of the present state of the discussion, and a more precise exposition of his own views with regard to it, than in any of his previous works. He comes more nearly to committing himself to definite propositions which can be tested and refuted or confirmed. The book, therefore, will both be more useful to the student and a more valuable contribution to science than any of its three precursors.

The illustrations are, we regret to say, of the same unsatisfactory character as in the previous volumes.

BOOKS RECEIVED.

Text-Book of Zoology. Part II.—Birds, Reptiles, Fishes. By Dr. Otto Schmeil. (Black.) Illustrated. 3s. 6d.

Microscopes and Scientific Instruments – Catalogue, 1900-1901. (C. Baker.)

Elementary Physics and Chemistry. Gregory and Simmons. (Macmillan.) Illustrated. 1s.

Outlines of Field Geology. 5th Edition. By Sir A. Geikie. (Macmillan.) 3s. 6d.

Photometrical Measurements. By Wilbur M. Stine, PH.D. (Macmillan.) 6s. 6d.

A Treatise on Zoology. Edited by Prof. E. Ray Lankester. *Part II.—The Poripera and Cœlentera* (Black.) 15s. net.

An Outline of the Theory of Thermodynamics. By Edgar Buckingham. (Macmillan.) 8s. net.

The Spectrum Plate. (Pamphlet.) By Miss Ackland.

The Path of the Sun, Illustrated by Diagrams. By William Sandeman. (Simpkin.)

The Journal of the Society of Comparative Legislation. August, 1900. (Murray) 5s.

Studies in Fossil Botany. By Dr. D. H. Scott, F.R.S. (Black.) Illustrated. 7s. 6d. net.

On the Rotation of Spiral Nebula Messier 51 Canum Venaticorum; Annual Report, 1899-1900, Savilian Professor of Astronomy; and other astronomical pamphlets. By H. H. Turner, Savilian Prof. of Astronomy.

The Birds of Ireland. By Richard J. Ussher and Robert Warren. (Gurney & Jackson.) 30s.

XUM

WIRELESS TELEGRAPHY.—IV.

By G. W. de Tunzelmann, B.Sc.

ELECTRIC WAVES.

As far back as 1842, the American professor, Joseph Henry, pointed out that the phenomena accompanying the discharge of a Leyden jar suggested that it was of an oscillatory character; and Helmholtz, in 1847, in his celebrated essay on the Conservation of Energy, made the same assumption, and pointed out that the oscillations would become continually smaller until the entire energy was dissipated by the opposing resistances. The time of a complete oscillation, as mentioned in my first article, is

$$T = 2\pi \sqrt{L S},$$

where L and S are the self induction and capacity of the circuit respectively.

The meaning of these electrical constants will be more clearly understood by a comparison of the electrical oscillations with mechanical oscillations of a simple character such as those of a straight spring fixed at one end and having a weight attached to the other.

The flexibility of the spring is the analogue of the capacity, and the inertia of the loaded spring that of self induction. An increase in either of them will diminish the rate of oscillation. In the electrical case the capacity of the circuit may be increased by making the jar larger, and as the self induction is due to the magnetisation of the medium surrounding the current it may be augmented by increasing the length of the circuit. Owing to the fact that there is very little magnetising effect, except close to the conductor, the area included in the circuit makes very little difference, so that the circuit may be wound into a coil, making the arrangement more compact. If the oscillations were slower the self induction might be still further increased by filling the space inside the coil with iron, but with these extremely rapid oscillations the iron is protected from magnetisation by the currents, opposed to those in the coil, which are induced by the latter in the outer skin of the iron, and the result is that the introduction of iron does not increase the self induction but actually diminishes it.

When the spring is set in motion the vibrations rapidly die away. This damping action is caused by the friction of the different portions of the spring, the energy of vibration being thereby dissipated into molecular vibrations or heat. It may be increased still further by immersion in a viscous medium, and if sufficiently viscous the motion may become *dead-beat*, that is to say, simply a single excursion and return to the position of equilibrium. Another cause of damping is the transference of energy to the medium by the production of waves in it, and if the spring is so shaped as to increase this effect the damping will also be increased. The electric oscillations which occur when a Leyden jar is discharged are damped in a very similar manner, the resistance of the circuit corresponding to friction, in the case of the spring, but in order to destroy its oscillatory character, except in the case of very large condensers, such as are used in submarine telegraphy, it is necessary to include in the circuit some very bad conductor, such as a wet string or a block of wood. The rapid damping of the oscillations of a Leyden jar discharge when the circuit is so designed as to be an efficient exciter of electric waves follows necessarily from the principle of the conservation of energy, just as in the case of the spring.

The Hertz oscillator, or exciter of electric waves, is simply a Leyden jar of such design as to facilitate the transference of the energy of the electric oscillations of its discharge to the surrounding ether, and therefore a comparatively large amount of energy is required to maintain it in action. Several years before Hertz's experiments were made, Professor Fitzgerald, of Dublin, had suggested, from theoretical considerations, that it should be possible to excite such electric waves in the ether by means of the discharge of Leyden jars of suitable design, and about the same time that Hertz began these investigations Professor Oliver Lodge was, in connection with the theory of the lightning conductor, making a series of experiments on the discharge of small condensers, which led him on to the observation of ether waves within the wires, and not waves transmitted by the material of the wires themselves.

As Hertz himself suggests, Professor Lodge would in all probability have succeeded in discovering the ether waves in air had he not anticipated him.

Hertz tells us that in 1886 he was experimenting with a pair of what he calls Riess or Knochenhauer spirals, but which should be more properly called Henry spirals, spirals of silk-covered copper tape first used by Professor Joseph Henry about 1838 in his researches on mutual and self induction. Hertz noticed that in order to obtain sparks in one of these spirals the large batteries which had hitherto been employed might be replaced by even a small Leyden jar, provided—and this was the important point—that the discharge was made to spring across a spark-gap. This observation led to the splendid series of researches which experimentally demonstrated the truth of Maxwell's theory of electromagnetic waves, and laid the foundation for the method of telegraphy which Signor Marconi and others have so successfully developed into a practical system.

It is well known to musicians as well as to students of acoustics that when a certain musical note is sounded, a string or pipe which would give out this note will respond to it, and in a similar manner an electric conductor may be adjusted or tuned to respond to the

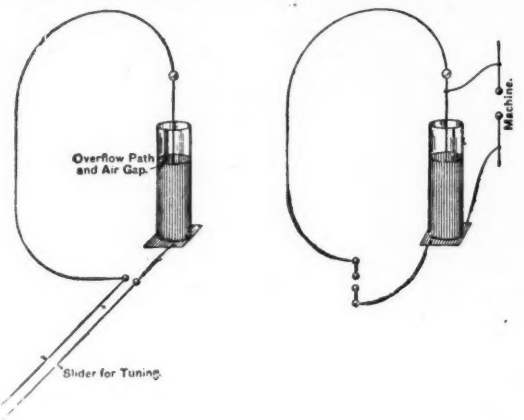


Fig. 1.—Lodge's Experiments with Syntonic Leyden Jars.
From Lodge's "Signalling through Space without Wires."

oscillations set up by the discharge of a Leyden jar. This is well shown in an experiment made by Professor Lodge after reading Hertz's papers. He took a pair of Leyden jars (Fig. 1) with circuits about a yard in

diameter, and separated by a distance of about two yards, and found that when the first jar was charged and discharged the waves set up in the second circuit could be made to cause it to overflow across a short air-gap, provided by pasting a slip of tinfoil over the lip of the second jar, by experimentally adjusting the slides shown in the illustration. Lodge calls this syntonising the pair of jars. A closed circuit such as this is a feeble radiator, because it is not well adapted for the transfer of its energy to the surrounding ether, some thirty or forty oscillations taking place before there is any serious damping. Great precision of tuning is therefore necessary.

It will be instructive to compare this arrangement of Professor Lodge's with a standard Hertz oscillator and resonator, as shown in Fig. 2. A powerful induction

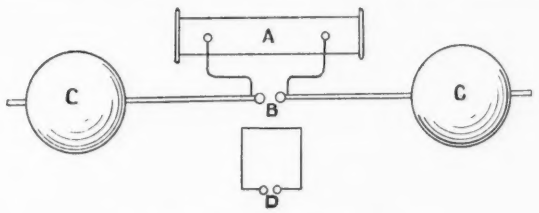


Fig. 2.—Hertz Oscillator and Resonator.

N.B.—C, C, are spheres with wires shown through centres, and therefore represented by circles. D is square of wire.

coil, A, having the terminals of its secondary circuit connected with the oscillator, which consists of a pair of brass rods terminating in small polished knobs, B, the distance between which is adjustable, while two large metal spheres, C, C, slide on the brass rods. By altering the positions of these spheres the oscillator can be tuned into syntony with the resonator, D, consisting of a wire rectangle or circle, terminating in a pair of polished brass knobs, which should be very close together.

If Lodge's exciting jar had its two coatings removed to a considerable distance apart, and the dielectric separating them were made to extend out into the room, we should obtain the equivalent of the Hertz oscillator, which is of the most suitable form to facilitate the transference of its electric wave energy to the surrounding ether. When the coatings are close together, as in Lodge's form, the magnetic energy largely predominates over the electrostatic. When the distance between them is increased and the dielectric more exposed, the electrostatic energy becomes more nearly equal to the magnetic, and therefore the arrangement gains in efficiency as a radiator, since in true radiation the two energies must

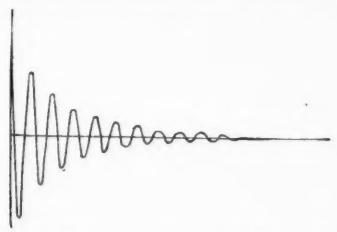


Fig. 3.—Oscillations of Dumb-bell Hertz Oscillator.

be nearly equal. The spheres, C, C, may, if desired, be replaced by large metal plates.

By means of calculations from the readings of an electrometer inserted in the air-gap, D, Fig. 2, Bjerknes succeeded in obtaining curves representing the damping of the oscillations. Figure 3 shows the oscillations obtained with a dumb-bell oscillator, such as that illustrated in Fig. 2, and it will be observed that they die away with extreme rapidity.

The persistent character of the oscillations excited in a ring resonator by an oscillator tuned to syntonism with it is shown in Fig. 4.

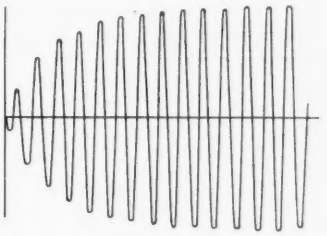


Fig. 4.—Oscillation of Ring-shaped Hertz Resonator excited by Syntonic Oscillation.

Just as in the case of acoustic resonance, when the resonator has its natural oscillations strongly damped, the tuning of the oscillator into syntony with it is of comparatively small importance, but if its oscillations are persistent then exact tuning is essential. Exact syntony is also necessary whenever the exciter is a persistent oscillator, as otherwise it will tend to destroy at one moment the oscillations which it set up a moment before. This is well shown in Fig. 5, which exhibits

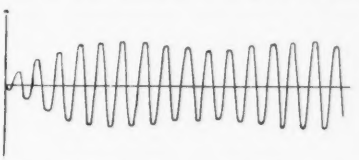


Fig. 5.—Oscillation of Ring-shaped Hertz Resonator excited by Oscillation not quite Syntonic with it.

the oscillation of a ring resonator, excited by an oscillation not quite in syntony with it.

To understand how an electrical oscillation, or its equivalent, an oscillating charged body, can excite electric waves in the ether, I will ask my readers to refer to Fig. 6 in my last article. Let the rack represent the electrically charged body, and imagine it is oscillating backwards and forwards in the direction of its length. This will set up a rotary oscillation in the wheelwork, and the wheelwork being, as has been assumed throughout, elastic, this rotary oscillation will be propagated with a velocity depending on the elasticity and the density, as has already been explained. The axes of the wheels represent the direction of the magnetic rotary oscillation, and this is perpendicular to the line of rack which represents the direction of the electrical oscillation. The direction in which the wave is advancing is perpendicular to both of them. Hertz by exploring with his resonator the space in the neighbourhood of an oscillator succeeded, not only in demonstrating the existence of electric waves, but in differentiating between the electrostatic and magnetic oscillations. He also succeeded in proving they had all the well-known properties of light and heat waves.

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The Discovery and Development of the Coherer.

Hertz's splendid results were all obtained with only the simple resonator shown in Fig. 2 as a detector of the presence of electric waves. This would, however, not have been nearly sensitive enough for transmitting signals over considerable distances, even with the most perfect oscillators or transmitting instruments, and each transmission, therefore, only advanced into the realm of the possible with the discovery of the microphonic transmitter, or, as Professor Lodge calls it, the *coherer*, which was not brought into general use for this purpose until years later, although it had been discovered and actually used for the detection of the presence of the Hertzian waves by that great and patient experimentalist, Professor Hughes (whose loss we have so recently had to lament), as far back as 1880, some half-dozen years before Hertz began his investigations.

His experiments were shown to Sir George Gabriel Stokes and other physicists in 1879 and 1880, but owing to their unfortunate failure to grasp the meaning of them as Hughes himself certainly did, their publication was deferred. The result was that Hughes found his own discoveries as to the sensitiveness of the microphonic contact, and its useful employment as a receiver for electrical ether waves, remade by others.

A capital historical sketch of the course of this discovery was given by Professor Lodge in the *Electrician* for November 12th, 1897, from which much of what follows has been taken. In this article he suggests that probably the earliest discovery of cohesion under electric influence was contained in a forgotten observation of Guitard in 1850, that when dusty air was electrified from a point the dust particles tended to cohere into strings or flakes, and points out that the same thing occurs in the formation of snowflakes under the influence of atmospheric electrification, and in the cohesion of small drops into large ones in the neighbourhood of a charged cloud forming the familiar thunder shower. In 1879, Lord Rayleigh showed that when a stick of rubbed sealing wax was brought within a few yards of a small fountain which was scattering its spray in all directions, the scattering ceased, the broken jet rising and falling in large heavy drops.

The next stage, with the exception of Professor Hughes's work, which it must be borne in mind remained unknown during the whole of the development described in what follows, was the re-discovery by Professor Lodge and the late J. W. Clark of Guitard's dust phenomenon when experimenting on the cause of the dust-free region of air discovered by Professor Tyndall as existing over hot bodies, and erroneously ascribed by him to the dust being burnt up, but which was shown by Lodge, Osborne, Reynolds and others to be really due to molecular bombardment, phenomena analogous to those occurring within a Crookes' radiometer.

Before, however, arriving at this explanation, experiments were made to see if it was caused electrically, and it was found that when the hot body was placed in a thick smoky atmosphere and then charged with electricity the smoky atmosphere immediately became clear. In 1889, Professor Lodge was investigating the action of the lightning guards used for protecting telegraphic instruments from the effect of the sudden rushes due to lightning discharges. These were made by adding as a shunt to the circuit containing the instrument, an open circuit with a small air-gap, with terminals consisting of a pair of small brass balls, across which the discharge jumped, rather than flow round the coils of the instrument, which had great self-induction, and therefore offered much opposition to a sudden rush of current. Lodge found that when the knobs were placed too close together even a Leyden jar discharge would often short circuit the gap, the knobs being found both by electrical and mechanical tests to be feebly united at a single point. When the knobs were in mechanical contact, and separated only by an extremely thin film, consisting probably of oxide, extremely feeble sparks were found to be sufficient to produce this effect. The adhesion of the two surfaces were demonstrated by means of an electric bell placed, together with a single battery cell, in the circuit, and every time a spark occurred the bell rang, and continued to ring until the table on which the apparatus was standing, or some part of the support of the knobs, was tapped, so as to shake them asunder again. The arrangement was found to form a convenient detector in the syntonic Leyden jar experiment described at the beginning of this article.

If the electric bell was placed on the same table as the sparking knobs, or, better, were allowed to touch them, its tremor was found to be quite sufficient to effect this separation, unless the spark and, therefore, the adhesion had been too strong. In the meantime, Hertz's experiments had attracted general attention from physicists. Professor Minchin, in 1891, when working with some photo-electric cells, and especially some which behaved abnormally, as it seemed to him at the time, and which he called "impulsion cells," found that when a Hertz oscillator was working in another part of the r om the electrometer connected with his cells responded, and by means of this detector, which certainly depended on the coherer principle, he succeeded in signalling without wires over a considerable number of yards.

Professor Boltzmann, about the same time, used a charged gold-leaf electroscope for a like purpose, arranging it so that the electroscope was just on the point of discharging across a minute air-gap, so that its leaves were deflected by a definite amount. It was found when in this condition to be extremely sensitive to Hertz waves, which, if excited in any part of the room, would bridge over the gap and discharge the instrument.

This, as Professor Lodge points out, is not a detector depending on the principle of cohesion, but it led him, when repeating the experiment in a modified form, to the conclusion that cohesion could be effected by the surgings due to the regular Hertz waves.

One of the modifications adopted by him was to make the gap of carbon, and to connect it, with its wave collector, to the terminals of the 110-volt electric light leads, so that whenever a Hertz oscillator was discharged across the gap, the spark would close the circuit and set up an arc. This method was suggested to him by the observation of the behaviour of some incandescent lamps used to light his lecture tables, which were shaded on one side, and prevented from rotating, by means of a pair of copper wires stretched across the lecture room. As long as the wires were there the lamp fuzes used to blow whenever a Hertz oscillator was worked in the room, owing to these wires acting as collectors, and they were therefore replaced by silk threads, when the fuzes ceased to blow.

In 1891, Professor Branly, of the Catholic Institute in Paris, published some experimental researches of the greatest importance, in which he showed that metals

in the state of powder or filings, and also various mixtures of metallic powders with non-conducting ones, which ordinarily offer an extremely high resistance to the passage of an electric current, fell enormously and quite suddenly in resistance whenever an electric spark occurred in the neighbourhood. This lowered resistance continued for some time, but the powder could be instantly restored to its high resistance state by tapping it, and in some cases by increasing the temperature. Branly found that when the powders had once been submitted to powerful electric action mechanical shocks did not restore them entirely to their original state, but that they continued to show themselves very much more sensitive to electrical actions. Some few bodies, such as peroxide of lead, had their resistance increased by the action of the electric sparks, and others again had their resistance alternately increased and diminished. The last results are curious and interesting, but the important case for its application to Hertzian telegraphy is that of diminished resistance. Branly's results became known to Professor Lodge at the end of 1893, when he at once proceeded to try the Branly tubes of filings, and found them greatly superior in manageability to either the Boltzmann gap or his own delicately adjusted cohering knobs, but immediately afterwards he, in conjunction with Professor Fitzgerald, devised a coherer consisting of a sewing needle resting upon aluminium foil, which they found to be of extraordinary sensitiveness and at the same time reasonably manageable. Professor Lodge then made a whole series of what he describes as quasi-optical experiments with the new detector, and, before long, various improved methods of arranging the filings were discovered, especially that of sealing them up *in vacuo* or in hydrogen, in order to protect them from oxidation by the air, the effect of which would be to produce too great a thickening of the extremely thin film separating them from one another. When brass filings immersed in hydrogen were used, they soon became too clean, and their sensitiveness so great that it was impossible to restore the original high resistance by tapping. Professor Lodge consequently preferred the vacuum obtained by the use of a Sprengel mercury pump. He states that almost any filings tube was capable of detecting signals sent from a distance of 60 yards, with a mere six-inch sphere used as oscillator, and without the slightest trouble, but that he found the single point coherer much more sensitive than any filings tube.

For tapping back, the use of an electric bell mounted on the base of a filings tube was not found very satisfactory, owing to the disturbances produced by the small sparks occurring at its contact breaker, to which this more delicate detector responded as well as to the signals which it was meant to attend to, while the less delicate knob apparatus had not been so affected. A tapper consisting of a rotating spoke wheel driven by the clockwork of a Morse instrument and giving the coherer a series of jerks at regular intervals was therefore employed.

Mr. Rolls Appleyard and Lord Rayleigh have devised a liquid coherer consisting of two globules of mercury separated by a thin film of grease, such as paraffine oil. When a battery cell is connected up in a circuit with these globules, they are pressed together every time the circuit is closed, and Lord Rayleigh has observed that it takes an appreciable time before they come into contact, as though a film had to be mechanically squeezed out from between the oppositely charged metallic surfaces, and this suggests that cohesion may in every case be simply a result of electrostatic attraction, and that the molecular films separating solids in contact may be squeezed out in a similar manner. The force of attraction between two surfaces differing in potential by a volt and separated by the smallest known thickness of thin film (which is about 10.7 centimetres) would be equivalent to about 650 pounds to the square inch, a quite sufficient pressure to make this explanation a perfectly possible one.

PLANTS AND THEIR FOOD.—V.

By H. H. W. Pearson, M.A.

We have now to consider the means by which the food constituents of the soil enter the plant and are carried upwards to the leaves; for it is in the cells of the leaves that the food supplies from the atmosphere and from the soil are brought together and undergo chemical changes. This important work of the absorption of mineral food from the soil is entrusted to the root, which in most cases serves the additional purpose of holding the plant firmly in position, and frequently also acts as a storehouse in which is laid by food or water for future use.

If a bean or pea be soaked in water until the embryo swells and bursts the seed-coat, it is seen to consist of two comparatively large and thick embryo-leaves or cotyledons, a minute bud or "plumule" between them, and, in a straight line with this, projecting beyond the cotyledons, a very small papilla, which is the embryonic root or "radicle." The cotyledons contain so much organic food material—starch and proteid—that the embryo in the early stages of its growth needs no root, but grows at the expense of these materials stored up for its use by the mother-plant. Meanwhile the tiny radicle insinuates itself between the soil-particles and grows downwards, and later gives off minor branches, and so becomes capable of laying the soil under contribution to supply the mineral needs of the commonwealth of which it forms a part, as soon as the stores in the cotyledons are exhausted. In many plants—*e.g.*, the Grasses—the radicle perishes almost as soon as it emerges from the "seed," and is replaced by numerous branches arising from the scar left by the defunct radicle or from the lower part of the stem or leaves.

The fact that roots grow downwards is so well known that mention of it may seem superfluous. This habit is due to the influence of gravity. It is easily noticed that the main root (produced by the continued growth of the radicle) is more strongly influenced by the force of gravity than are its side-branches, for while it strikes a course which is, in the main, towards the earth's centre, its branches make a considerable angle with it, and frequently grow in a horizontal direction. Consequently the roots are able to exploit a much larger area of soil than would be possible if the branches and the main root were equally amenable to gravity. A further peculiarity in the growth of most roots is that they shun the light and take the shortest course to dark or shady places. On an ivy stem the clinging roots by which it is attached to the wall or tree all emerge on the shady side of the stem and proceed at once to bury their sensitive tips in the nearest hollows of the support. There are, on the other hand, roots which behave like stems, in that they bid defiance to gravity and grow erect and show no tendency to hide themselves from the light. These, however, are quite exceptional, and as a rule serve the plants which pro-

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duce them in other ways than by the absorption of food. These two characters possessed by most roots—viz., a tendency to grow (1) in the direction of gravity and (2) away from the light—cause them to penetrate the soil in which their quest (mineral food) is to be found.

The soil varies considerably in composition, and even within small areas the distribution of moisture—and therefore of available plant-food—is by no means uniform. Roots have a third character, which enables them to follow such a course in the soil that they tap the places most richly supplied with moisture and nutriment. The root-tip is extremely sensitive to moisture, and will travel through the moister parts of the soil even if by so doing it leaves the more direct downward course dictated by gravity. This fact is of immense importance to the root in its search for food, for it is guided, as by an unerring instinct, to just those places where food in an available form is to be found. It is not difficult to see for oneself evidence of this interesting behaviour of the root in the presence of moisture. A sieve is made by fastening some netting to a box from which the bottom has been removed; it should be about two inches deep and eight inches from side to side. The sieve is filled with moist sawdust in which some barley grains are sown, and then hung up in a greenhouse* in such a way that the netted surface makes an angle of 45° to 50° with the vertical. As the roots grow through the bottom of the sieve the attraction exercised by the moisture in the sawdust overcomes the effects of gravity and they are deflected from the vertical and grow downwards along the inclined surface of the sieve.

The younger parts of the root are provided with so-called "root-hairs," the organs actually concerned in bringing into the plant the mineral solution of the soil. Each hair is produced by the elongation of a single cell of the root surface.† They appear on the young part of each branch of the root a little distance behind the apex, and fall off as it becomes older and thicker. Only those parts of the root which are provided with "hairs" are able to take in solutions from without. They are usually thickly placed on that part of the root where they occur, and very short—as a rule, much less than $\frac{1}{8}$ of an inch long, but sometimes $\frac{1}{4}$ inch or more. Their formation is much influenced by the conditions under which the root grows, for they are more abundantly developed in a moderately dry than in a very wet soil. On the other hand, if the soil be very dry, or so compact and hard as to offer much resistance to the growth of the root, their formation is hindered. The connection between the root-hairs and the soil particles is very intimate; this is seen on uprooting almost any young plant, when it will be found very difficult to remove the last traces of soil from the younger parts of the root. The root-hair, choosing in its growth the path of least resistance, comes into close contact with particles of soil at various points; at the places of contact its cellulose wall becomes soft and jelly-like, so that the particle is more or less embedded in it.‡

The root-hair is merely a long cell, and, like other living cells,§ is surrounded by a cellulose wall, on the inside of which is a lining of semi-fluid protoplasm. As much of the cell as is not occupied by protoplasm is filled by the cell-sap, a solution of organic and inorganic substances. Outside, the root-hairs are bathed by a weak solution of mineral salts, the water of the soil. There are thus two solutions separated from one another by a double wall, the outer of cellulose and the inner of protoplasm.

The cellulose wall being very minutely perforated,‖ the two solutions are provided with passages by which they can communicate. Under these circumstances physical forces are called into play, and the fluid particles in the minute passages in the cell-wall are set in motion. Owing to the presence in the cell-sap of various organic substances in the plant-cell, the solution in the soil passes into the cell, which becomes in time full and the elastic cellulose wall distended—a condition in which the cell is called "turgid." The pressure within the cell, which may be as much as four or five atmospheres, is then only relieved by the transference of some of the cell-sap onwards to other cells. The root-hair thus obtains the nutrient solution which it seeks by the purely physical process of osmosis, and passes it on to the interior cells.

If the wall separating the cell-sap and the soil solution consisted of the cell-wall only, without the lining of protoplasm, the passage of solution into the cell would take place in the same manner, but certain modifications are caused by the presence of the inner wall of living protoplasm. If a slice of fresh beet-root be carefully washed and placed in clean cold water no red colouring matter escapes, but the water remains clear and colourless. On heating, a change occurs; when the water is boiled it is coloured red by the sap which escapes from the cells of the beet-root. As long as the protoplasm lining the cell-wall is living it prevents the coloured sap — and other substances as well — from escaping, but as soon as it is killed, by raising the temperature or in other ways, it loses this power and the sap diffuses through it into the water. The living protoplasm thus exercises some control over the dissolved substances which leave and enter the cell; and, further, a solution which enters at one time is unable to escape at another. It is probable that the constitution of the protoplasm varies from time to time, though in what precise manner and under the influence of what cause or causes it does not at present admit of explanation. The fact remains that the protoplasm as long as it is alive prevents some substances from entering the cell and others from leaving it. Despite this control, a large quantity of mineral matter enters the plant which is of no use to it as food and may indeed be harmful. We have noticed in the case of Silica¶ an instance of the absorption of large quantities of a substance which is of no food-value to the plant.

The roots of many plants not only absorb mineral food from the soil but are also manufactories in which the transformation of free Nitrogen into an oxidised state occurs. It has long been known that agricultural land is improved by ploughing into it the remains of previous crops, and that the benefit derived is greater in some cases than in others. Nearly 300 years ago Bacon wrote**:—"The Fourth Helpe of Ground is the

* Or in a dark room: in this case the floor of the room should be occasionally watered, that the air may not become so dry as to cause the withering of the roots.

† *See* figure in Knowledge, July, 1900, p. 160, *h*, *h'*.

‡ *See* figure in Knowledge, July, 1900, p. 160, *s*, *h*.

§ Knowledge, January, 1900, p. 3.

‖ Knowledge, January, 1900, p. 3.

¶ Knowledge, May, 1900, p. 101.

** "Sylva Sylvarum," p. 146.

Suffering of Vegetables to die into the Ground; And so to Fatten it; As the Stubble of Corne, Especially Pease." Equally beneficial with "Pease" are other crops, such as clover, belonging to the Natural order Leguminosæ (so-called because its members produce a fruit known as the "legume" or "pod"). The roots

A Lupine Plant, reduced from a drawing by Miss E. E. Pratt, showing the tubercles (*t*) on the roots.

of many plants belonging to this order are swollen or knotted at intervals like that of the garden Lupine shown in the figure. Similar tubercles are sometimes found also on the roots of the Alder and a few other less familiar trees and shrubs. Needless to say, they were observed long before their importance to the plant was realised. On examining a section cut through one of them, it is seen that the tissues of the root have been stimulated to increased growth, causing the part affected to swell. Such an abnormal growth of an organ is often caused by the presence within it of a foreign organism. And so it is in this case, for in the cells of the tubercle is a multitude of minute residential organisms to which we hesitate to apply a name. In some stages of their existence they resemble bacteria, by which name they are frequently called. Their exact nature is, however, still under discussion; it is certain that they are not true bacteria, but probably the degraded descendants of ancestors belonging to one of the lower groups of the Fungi. The work done by these tubercle-organisms has been studied only in a few members of the Leguminosæ, but it is probable that wherever they are found they are equally important to the plant in whose roots they live. On some roots the tubercles are found in large numbers; more than 4,500 have been counted on a single pea-plant.

In a previous article†† it has been noticed that most green plants obtain their Nitrogen in the form of Nitrates (*i.e.*, oxidised Nitrogen), and that they are unable to make use of the free Nitrogen of the atmosphere. When certain leguminous plants, such as the Lupine, are grown in soil which contains no Nitrates, they may die from Nitrogen starvation, or, on the other hand, they are more likely to grow in normal luxuriance. If the plants which die under these circumstances are examined their roots are found to be quite free from tubercles; while the roots of those which flourish are invariably provided with tubercles, in the cells of which is the usual population of organisms. If the soil is strongly heated and then allowed to cool before the Lupine is planted in it, and afterwards carefully protected so that no impurities from outside may reach it, the roots grown in it do not become swollen, *i.e.*, they are not invaded by the organism which causes the swellings. The organism is present in the soil, and under ordinary circumstances "infects" certain roots, such as those of the Lupine; but if the soil has been previously heated, bacteria and other living inhabitants are killed, and roots grown in it afterwards do not become infected. What the Lupine and similar plants require in the soil is not an abundant supply of Nitrates but the presence of the minute organism which infects and establishes colonies in its roots.

The facts of the last paragraph clearly indicate that the work of the root-organism consists in the production of compounds of Nitrogen which can be made use of by the plant which gives it lodging and partial "board." As a result of much careful and reliable investigation we now know that the free Nitrogen of the atmosphere‡‡ is oxidised by the activity of these humble guests, and the resulting Nitrates are passed on to the host-plant. The latter not only houses its guests during their life-time but apparently also consumes their remains after death, thereby doubtless making use of the stores of accumulated nitrogenous compounds in their bodies. This is one of the most promising fields of future investigation, and many interesting results may yet be expected from it. For the present, we must realise that we know very little about the details of the co-operation between the flowering plant and the soil-organism—a union which was not suspected two or three decades ago. We are at least certain that some leguminous plants are rendered independent of supplies of Nitrates in the soil by reason of the activity of minute soil-organisms which reside in their roots, assimilate free atmospheric Nitrogen and pass it on to their host in an oxidised state. At the end of the growing season the root of such a plant contains a store of nitrogenous substances ready to be absorbed by plants whose existence depends upon a supply of oxidised Nitrogen. The roots of a crop of leguminous plants such as "Pease," left to decay in

†† July, 1900.

‡‡ All soils contain air, and therefore free Nitrogen. *See* figure in KNOWLEDGE, July, 1900, p. 160.

XUM

the soil, enrich it by adding to it such compounds of Nitrogen, and thereby render it more fertile the next season for a crop which possesses no means of utilising the free Nitrogen of the air.

NOTES ON COMETS AND METEORS.

By W. F. Denning, F.R.A.S.

Borrelly-Brooks's Comet.—This object has formed a very interesting one for telescopic observers during the last two months. It has exhibited a well defined tail and bright head; in fact its aspect has been that of a large comet presented in miniature. Its motion away from the earth and sun has now rendered it extremely faint, and it will soon pass beyond the range of the most powerful telescopes. At the beginning of October the position of the comet is 5 degrees S.W. of the stars $\beta - \gamma$ Ursae Minoris, and its motion is directed towards the S.E., but it is now apparently travelling very slowly. A very large number of observations of this object have been obtained at observatories in various parts of the world. Its orbit appears to be parabolic, but definite elements have not yet been computed.

Barnard's Comet (1884 II.).—In Ast. Nach. 3660, A. Berberich gives a sweeping ephemeris of this object. Its perihelion passage will probably take place at the end of October, but the precise date is uncertain. On October 23 the computed place of the comet will be R.A. 17h. 31m., Dec. $-27°$ 12′, but its southerly position and great distance (nearly 150 millions of miles) from the earth must prevent its being seen in this country except in a very powerful telescope. The comet was discovered in 1884, and has a period of about $5\frac{1}{2}$ years. It must have returned to perihelion in 1890 and 1895, but escaped observation on both occasions. It seems probable that, in view of the unfavourable conditions, the comet will again elude detection during its present return.

Fireballs.—A considerable number of these objects have been reported from various places during the past two months. In the majority of cases, however, the observations are not sufficiently full and accurate to enable the real paths of the meteors to be computed. On July 30, at 10h. 46m., a very brilliant Perseid was seen from the S.W. part of England and from Jersey. It fell from a height of about 95 to 50 miles over the English Channel, S. of Cornwall. On August 12 several brilliant fireballs appeared in the moonlight. Two are described by the Rev. T. E. R. Phillips of Yeovil. One of these was seen at 10h. 21m., and was brighter than Venus. It travelled from $291\frac{1}{2}° + 30°$ to $271° - 7°$, and was a fine Perseid. The other came two minutes later, and shot from $252° + 24°$ to $195° + 59°$, and was probably directed from the same radiant as the fireball of July 24 at $280° - 15°$. On August 19, 10h. 36m., the end point of a brilliant fireball was observed by the writer at Bristol at $198° + 26°$, and the same object was seen at Yeovil by the Rev. T. E. R. Phillips, and at places in Ireland by other observers. Its radiant point was at $346° + 1°$, and it descended from 56 to 29 miles over the east coast of Ireland, but only the latter portion of the flight seems to have been satisfactorily recorded. When the fireball first became visibly incandescent it was probably much higher than 56 miles, and it is hoped that further observations of it will come to hand. On August 22, 10h. 8m., a fine meteor estimated equal to Jupiter was seen by Mr. A. King at Leicester, and by the writer at Bristol. It proves to have been a Cygnid from a radiant at $310° + 53°$, and having heights of 75 to 50 miles.

Large Daylight Meteor of September 2.—Just before sunset on September 2 at 6h. 54m. a magnificent meteor was seen from the northern counties of England and from Scotland. A considerable number of descriptions have appeared in the newspapers, and Mr. W. H. S. Monck, of Dublin, has collected and kindly furnished me with many of these. The meteor appeared at a time when there were no stars or planets visible by which to mark its apparent path, hence the accounts give positions which were only roughly estimated. A full discussion of the materials has not yet been attempted, but it appears certain that the meteor disappeared over Lancashire at a height between 20 and 25 miles, and that it was directed from a radiant probably in Cepheus at $334° + 57°$. At Bristol 5 meteors were observed from the shower later on the same night but they were small. The faintest meteors and the largest fireballs are, however, directed from the same radiant points.

August Shooting Stars.—The full moon of August 10 practically obliterated the Perseids at and near the time of maximum display this year, but a few of the usual streak-leaving meteors of this prominent system were noticed at various places. They appear to have been most numerous on the very clear night of August 12. The change in the position of the radiant was noticed by several observers. At Bristol, between August 16 and 26, in watches extending in the aggregate over 15 hours, 125 meteors were observed. The chief shower was at $346° + 1°$ (12 meteors), and there was another active radiant at $333° + 28°$ (11 meteors). The Perseids still exhibited striking activity on August 16, and indicated a radiant at $54° + 58°$. On August 22 about 5 streak-leaving meteors gave a good centre at $59° + 59°$, which is close to the computed place of the Perseid radiant, but there is a shower of Camelopardids from this point, and it is possible that the meteors were not real Perseids. The observations are, however, very significant that the Perseid shower continues until August 22. This was distinctly suggested by Lieut.-Col. Tupman's observations in the Mediterranean in 1870, but I recognised very little if any evidences of the prolongation of the shower on August 22 in the years 1879, 1884, and 1887, when I registered a considerable number of meteors on this date. The point is an interesting one. It will be important to learn in future years the visible strength of the shower on the nights intervening between August 16 and 22. The radiant is very well defined on the former date, but before assuming that it continues in action to the 22nd we must thoroughly watch for it on the immediately previous nights, and this will enable us to assign definite limits to the showers' sustenance. From the writer's own observations at Bristol there can be no doubt that Perseids continue to fall as late as August 19, but the Perseid-like meteors seen on following nights may belong to a distinct shower in Camelopardus, very well defined earlier in the month, and notably on August 16 at the point $61° + 60°$.

Microscopy.

By John H. Cooke, F.L.S., F.G.S.

Mr. G. H. J. Rogers, F.R.M.S., has invented an improved form of compressor for which the principal advantage claimed is the ready replacement of the cover glass in the event of it being broken by accident.

Chinese cement is composed of finely powdered calcined lime 54 parts, alum 6 parts, fresh blood 40 parts. These are worked into a homogeneous mass. Pasteboard saturated with it will become as hard as wood.

One of the difficulties experienced by those who keep fresh water aquaria for the purpose of cultivating material for microscopical study or class work is the rapid decay of the plants, due in a measure to the ravages of the bacterial zooglœa that form on the surface of the water. To prevent this, the water must be supplied with oxygen by growing in it some good aerating plants like Myriophyllum, Cabomba, Ranunculus, water mosses, etc. Algæ like Vaucheria, Spirogyra, Chara, Nitella, Coleochaeta, Oedogonium, will thrive and fruit provided that the conditions are suitable. Where the aerating plants themselves do not thrive algæ may be successfully cultivated, provided that means be adopted to protect the surface of the water so as to exclude dust, but permit free access of air. If the aquaria are small, this may be readily effected by covering them with loose glass covers; but, where they are large, a better method is to encourage the growth of the floating plant Salvinia nutans, which propagates rapidly and protects the surface from the accumulation of bacterial zooglœa. Plants such as Azolla or Lemna would perform the same functions, but both of these have their periods of decay when they disappear altogether, while the Salvinia is in evidence all the year round.

A supply of fruiting Vaucheria may be obtained at any time of the year by carefully removing the mats from pots in greenhouses, and throwing them into a jar half full of water. The jar should be placed in strong sunlight, and in five or six weeks the material may show both methods of reproduction and will be practically free from dirt and other algæ.

Fresh water rhizopods are more common in the ordinary collections of the microscopists than is generally supposed, but since they are seldom looked for they are often passed by unnoticed. In systematic collections the superficial ooze at the bottom of still water should be examined, after it has been allowed to settle for some time in a suitable vessel. Rhizopods are common in the slime of submerged rocks, stems, and leaves, especially so in moist Sphagnum; they are to be found almost everywhere in moist situations not too much shaded, among decaying logs, mosses, lichens, and on the bark of trees.

The motion of camphor in water is well known. A German chemist, K. Schaum, has taken such readily soluble substances as potassium cyanide, potassium nitrate, silver nitrate, calcium chloride, and sugar, and has studied their travels in dissolving with the aid of the microscope by dropping single crystals upon mercury covered by water or dilute acid. The movements—greater in dilute acid than water—are very characteristic. The crystal first takes a zigzag course, then changes to a circular path, and finally turns rapidly on its axis. The rate of motion varies with the rate of solution and the surface tension of the mercury.

Particles of sand and gravel in the alimentary canal of earthworms that are being prepared for sectioning, and that may injure the edge of the microtome knife, can be removed by feeding the worms on bits of filter paper before killing them.

Microscopists will be interested to know that certain kinds of glass appear to be so soluble in water that moisture quickly etches the surface and destroys the transparency. Mr. E. F. Mondy, of Decca College, East Bengal, reports having noticed the dull matt appearance of a cut wineglass and of finger bowls in which water had been allowed to stand: also the spotting of two decanters which had been dried after partial draining. These effects were all due to water-etching. This explains the rapid deterioration of optical apparatus in the moist climate of India. Proof that the fault is in the kind of glass used is furnished by the object-glass of a 3½ inch telescope, the inner surface of the convex lens being badly corroded whilst the adjacent face of the concave lens was quite clear.

To avoid many of the failures that fall to the lot of the photo-micrographer, the details of each experiment that is made should be systematically recorded so that the operator may have a guide on other occasions when the conditions are similar. For this purpose a book should be kept containing spacings for details regarding the objective, light, distance of light from object and plate, colour of object, plates, screens and time of exposure.

Great care and cleanliness are necessary in all microscopical work, but particularly in the study of powdered substances. Dust and all other foreign matter must be carefully removed from slides and covers. Great caution must be observed so as not to get different powders mixed. The same slide should never be used for different powders unless special care has been observed in cleaning them. If several slides are being prepared for examination be sure to label them, otherwise confusion is sure to follow.

Of all the media employed for the mounting and preservation of objects Canada balsam is the most generally useful, and it is probable that more objects are mounted in this material than in all others put together. It is perfect as a preservative, and its action in rendering many objects transparent is often of great value. Much of the Canada balsam that is sold is made of cheap resins dissolved in impure turpentine, and this explains many of the difficulties and failures that fall to the lot of the microscopist. To be good Canada balsam should be of thick consistence, nearly colourless, and thoroughly transparent.

In mounting objects in balsam the great difficulty to be encountered is the presence of air bubbles. Judicious management, however, enables one to avoid them. In the first place all bubbles should be removed from the balsam on the slide. This is more easily done before immersing the object in the balsam than afterwards. Next see that the air is expelled from the object; and lastly, that no air enters with the cover. To do this the cover should be made hot, and then slowly lowered on the balsam from one side.

Dr. E. J. Spitta finds that, when taking photographs of living bacteria such as the clumping of the typhoid germs in Widal's method of diagnosis, it is best to take advantage of diffraction effects and to close the iris to what would otherwise be considered an undue amount. By this means a faint "standing out" effect is produced which enables the bacteria to show sufficiently for the purpose, provided the exposure be short enough to prevent choking effects, and yet long enough to give a sufficiently dense background. He finds that ten seconds is sufficient with a subdued light, and using a one-sixth apochromatic objective. A vertical apparatus must be used.

To mount the antennæ of flies, wasps, and bees, it is necessary to soak the objects in chlorate of potash, with a few drops of hydrochloric acid, until they are colourless, and then mount in Canada balsam and benzole. The points requiring attention are these: soaking just the right length of time in the potash, for if the object remains too long in the liquid it will be destroyed; and manipulating it when mounting so as not to destroy the characteristic features.

[*All communications in reference to this Column should be addressed to Mr. J. H. Cooke at the Office of* KNOWLEDGE.]

THE FACE OF THE SKY FOR OCTOBER.

By A. FOWLER, F.R.A.S.

THE SUN.—On the 1st the sun rises at 6.2 and sets at 5.38; on the 31st he rises at 6.53 and sets at 4.35.

THE MOON.—The moon will enter first quarter on the 1st at 9.11 P.M.; will be full on the 8th at 1.18 P.M.; will enter last quarter on the 15th at 9.51 A.M.; will be new on the 23rd at 1.27 P.M.; and enter first quarter again on the 31st at 8.18 A.M. The following are among the principal occultations visible during the month:—

Date.	Name.	Magnitude.	Disappearance.	Angle from North.	Angle from Vertex.	Reappearance.	Angle from North.	Angle from Vertex.	Moon's Age.
				°	°		°	°	d. h.
Oct. 1	B. A. C. 6347	6·0	8.32 P.M.	82	58	9.41 P.M.	249	217	7 25
,, 2	B. A. C. 6710	6·0	10.8 P.M.	31	2	10.58 P.M.	290	256	8 26
,, 7	κ Piscium	5·0	1.35 A.M.	38	7	2.29 A.M.	272	236	13 6
,, 11	ω² Tauri	4·6	8.47 P.M.	33	74	9.25 P.M.	305	346	17 25
,, 14	ν Geminorum	4·0	3.0 A.M.	40	68	3.43 A.M.	333	353	20 7
,, 29	δ Sagittarii	4·9	8.27 P.M.	358	327	8.46 P.M.	325	292	6 8

THE PLANETS.—Mercury is an evening star throughout the month, at greatest eastern elongation of nearly 24° on the 30th, but is too far south to be easily observed in our latitudes.

Venus remains a morning star, rising on the 1st about 1.45 A.M., and on the 31st about 2.50 A.M. The planet is in Leo until the 28th, and will be less than a degree south of Regulus on the 7th. At the middle of the month the diameter of the planet will be 18".4, a little more than six-tenths of the disc being then illuminated.

Mars rises a little before midnight throughout the month, and is gradually becoming more favourably placed for observation. The planet has an easterly motion, passing from Cancer into Leo about the 25th. On the 15th, the apparent diameter of the planet is 5".8, and the illuminated part 0.902; the distance of the planet from the earth at this time is nearly 149 millions of miles.

Jupiter is still an evening star, in Scorpio, but too close to the sun for observation, except under very favourable circumstances. At the beginning of the month the planet sets before eight o'clock, and at the end of the month soon after six.

Saturn remains an evening star, in Sagittarius, setting soon after 9 P.M. on the 1st, and about half-past seven on the 31st.

Uranus is an evening star, but so near the sun, and so low, that it may be considered not observable.

Neptune rises soon after 9 P.M. on the 1st, and soon after 7 P.M. on the 31st. He is stationary on the 2nd, and afterwards describes a short westerly path in Taurus, almost midway between 132 Tauri and Eta Geminorum.

THE STARS.—About 9 P.M. at the middle of the month, Auriga and Perseus will be in the north-east; Taurus low down in the east; Aries, Pisces, and Cetus in the south-east; Andromeda and Cassiopeia high up and a little south of east; Pegasus and Aquarius in the south; Cygnus high up to the south-west; Aquila a little lower in the south-west; Lyra and Hercules towards the west; Corona towards the north-west; and Ursa Major in the north.

Minima of Algol will occur on the 9th at 10.40 P.M., and on the 12th at 7.29 P.M.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. Locock, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of September Problems.

No. 1.

(N. M. Gibbins.)

1. Kt to Kt3, and mates next move.

No. 2.
(C. D. Locock.)
1. P to Kt5, and mates next move.

Correct Solutions of both problems received from Alpha, H. S. Brandreth, G. A. Forde (Capt.), W. de P. Crousaz, G. W. Middleton, C. F. Pilcher, K. W.

Of No. 2 only, from H. Le Jeune.

P. G. L. F. and W. Geary.—Many thanks for the problems.

H. Le Jeune.—If 1. Q to R3, B × Kt, and there is no mate.

P. Val Blagy.—There is no solution competition in progress, though I hope to be able to arrange one shortly. In the mean time I venture to reply that the reason why solvers send in their solutions lies in their desire to show that they take an interest in the problem department of this page. Your solutions are incorrect. In No. 1 the Knight cannot mate at Q6 on account of the Black Pawn standing at QB2. In No. 2, after 1. B to Kt2ch, Kt × B, the White Queen, being pinned, cannot mate at Q3. This pinning of the Queen, whenever the Black Knight next to it moves, being indeed the main point of the problem.

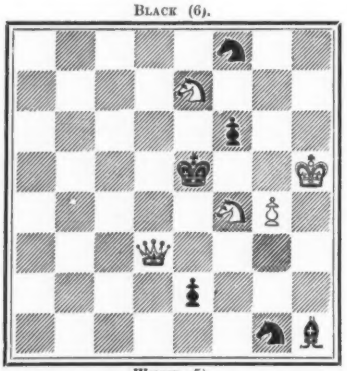
C. F. Pilcher.—You will see that both your first attempts have proved correct.

PROBLEMS.

By W. Geary.

No. 1.

Black (6).

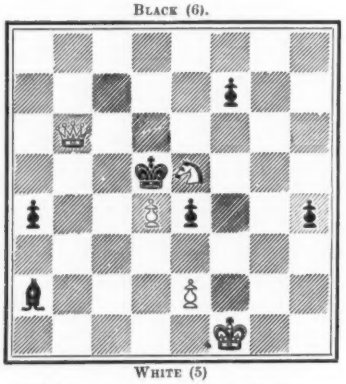


White (5).

White mates in two moves.

No. 2.

Black (6).



White (5)

White mates in three moves.

CHESS INTELLIGENCE.

The Amateur Tournament of the Southern Counties' Chess Union, which carries with it the Newnes Challenge Cup and the Amateur Championship, began at Bath on September 3. There were 15 entries in the chief event, and Mr. H. E. Atkins again carried off the first prize without losing a game, scoring 12½ out of a possible 14. Mr. Herbert Jacobs was a good second with 11½, and Mr. Jones Bateman third with 10. The other competitors were Messrs. H. H. Cole, W. Ward, F. J. H. Elwell, B. D. Wilmot, A. Rumboll, E. B. Schwann, J. F. Allcock, P. R. Gibbs, J. E. Parry, A. L. Stevenson, C. J. Lambert, and F. Brown.

It is with great regret that we announce the death of Sheriff Spens, of Glasgow, for many years one of the leading players in Scotland, deservedly also one of the most popular. He was for many years chess editor of the *Glasgow Weekly Herald*, and the founder of the Scottish Association in 1884. He was distinguished also in literature as in chess.

The death of William Steinitz removes the most notable player of the past generation. He won the Chess Championship by his victory over Anderssen in 1866, and held it against all comers till his defeat at the hands of E. Lasker in 1894. During this long period he engaged in a very large number of matches, his most noteworthy opponents being Zukertort, Blackburne, Mackenzie, and Tchigorin. In all of these he was uniformly successful, generally by decisive majorities. In fact it was specially as a match player that Steinitz was supreme. A long series of games gave him time to recover from a bad start generally due to rash experiments in the openings. It was characteristic of the man that he would stick to these unsound ventures long after all experts had demonstrated their unsoundness. But for this he would have been an even more successful tournament player than he was, though in this branch of play he was certainly one of the best. The Steinitz Gambit cost him many games, as did strange defences to the Ruy Lopez, and attacks against the French Defence. This put him at a great disadvantage with all his fellow competitors. Every one knew what defence or attack Steinitz would play in any particular opening, and the weaker players were coached by the stronger to rob him of many a game. No one could be more brilliant than Steinitz when he chose (witness the often quoted game against Bardeleben at Hastings), but he preferred to win his games by the logical scientific method of which he was the inventor, christened by him "the accumulation of minute advantages." He did not care to slay his antagonist suddenly but preferred the method of slow strangulation. As a writer on the game he was painstaking and suggestive, if not always reliable, unrivalled too as an annotator of games. No player since Paul Morphy has had a greater or better influence on the game.

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